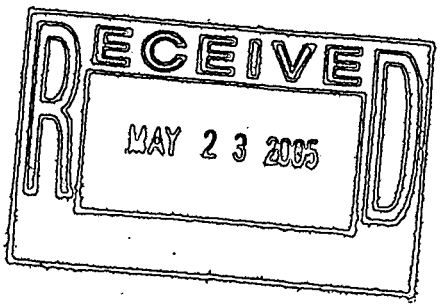
# ANNUAL REPORT
# FOR THE

# ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

# GROUNDWATER PLUME TREATMENT SYSTEMS

## January through December 2003




**January 31, 2005**



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## ACRONYMS & ABBREVIATIONS

| | |
|---|---|
| AL | Action Level |
| ALF | Action Level Framework |
| CAD/ROD | Corrective Action Decision/Record of Decision |
| CDPHE | Colorado Department of Public Health and Environment |
| CHWA | Colorado Hazardous Waste Act |
| CWTF | Consolidated Water Treatment Facility |
| DCE | dichloroethene |
| DOE | U.S. Department of Energy |
| EPA | U.S. Environmental Protection Agency |
| gpm | gallons per minute |
| GW | groundwater |
| HRC® | Hydrogen Release Compound® |
| IHSS | Individual Hazardous Substance Site |
| IM/IRA | Interim Measure/Interim Remedial Action |
| IMP | Integrated Monitoring Plan |
| ITS | Interceptor Trench System |
| K-H | Kaiser-Hill Company, L.L.C. |
| mg/kg | milligrams per kilogram |
| mg/l | milligrams per liter |
| MIP | material insertion point |
| msl | mean sea level |
| ORP | oxidation-reduction potential |
| OU | Operable Unit |
| PAM | Proposed Action Memorandum |
| PCE | tetrachloroethene |
| pCi/l | picoCuries per liter |
| PL | Present Landfill |
| POC | point of compliance |
| PU&D | Property Utilization and Disposal |
| RCRA | Resource Conservation and Recovery Act |
| RFCA | Rocky Flats Cleanup Agreement |
| RFETS | Rocky Flats Environmental Technology Site |
| RMRS | Rocky Mountain Remediation Services |
| SAP | sampling and analysis plan |
| SCFA | Subsurface Contaminant Focus Area |
| SITE | Superfund Innovative Technology Evaluation |
| SPP | Solar Ponds Plume |
| TCE | trichloroethene |
| uCi | microCuries |
| ug/kg | micrograms per kilogram |
| ug/l | micrograms per liter |
| UHSU | Upper Hydrostratigraphic Unit |
| VOC | volatile organic compound |

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## 1.0 INTRODUCTION

This report describes the January 2003 through December 2003 activities and performance monitoring data for the Mound Site Plume, East Trenches Plume, and Solar Ponds Plume groundwater collection and treatment systems, and the Property Utilization and Disposal (PU&D) Yard treatability study at the Rocky Flats Environmental Technology Site (RFETS). These systems and the treatability study were installed in accordance with Rocky Flats Cleanup Agreement (RFCA) accelerated action decision documents.

This report presents an evaluation of the three groundwater collection and treatment systems in relation to the remedial objectives for these systems, since these systems have about five years of operational experience. The goal of this evaluation is to determine whether the systems are operating properly and successfully. Based on the evaluation presented in this report, these systems meet the remedial objectives and are thus operating properly and successfully.

Table 1 summarizes these six projects and the groundwater treatment employed at each. The Operable Unit-1 (OU-1) and OU-7 groundwater treatment systems are briefly discussed, but a remedial objective evaluation is not presented for the reasons described below.

**Table 1. Groundwater Treatment Projects at RFETS**

| Project | Contaminant Type | Treatment Type |
|---|---|---|
| Mound Site Plume Treatment System | Volatile Organic Compounds (VOCs)<br>Radionuclides | Collection trench with passive, zero-valent iron treatment cells |
| East Trenches Plume Treatment System | VOCs | Collection trench with passive, zero-valent iron treatment cells |
| Solar Ponds Plume Treatment System | Nitrates<br>Uranium | Collection trench with solar-powered pump and passive treatment cells containing wood chips and zero-valent iron |
| OU1 - 881 Hillside Groundwater Treatment System | VOCs<br>Radionuclides | Treatment discontinued in 2002. |
| OU7 - Present Landfill Passive Seep Interception and Treatment System | VOCs | Passive seep interception system with passive aeration treatment – Current system will be replaced and relocated in 2005. |
| PU&D Yard Plume Treatability Study | VOCs | Treatability study - In situ bioremediation using Hydrogen Release Compound (HRC)® |

The OU-1 – 881 Hillside Groundwater Treatment System operation was discontinued in April 2002, in accordance with the *Final Major Modification to the OU-1 CAD/ROD* (DOE 2001). The 2003 sampling and analysis results are contained in the 2003 Annual Groundwater Monitoring Report (DOE, 2004a).

At OU-7, a RFCA accelerated action to install a Resource Conservation and Recovery Act (RCRA)/Colorado Hazardous Waste Act (CHWA) compliant cover is being implemented in accordance with the *Interim Measure/Interim Remedial Action for the Present Landfill* (PL IM/IRA) (DOE, 2004b). The major components of the OU-7 Treatment System will be removed

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and replaced with new or upgraded components and relocated based on the final configuration of the landfill cover. See the PL IM/IRA for details about the groundwater treatment system.

The Mound Site Plume, East Trenches Plume, and Solar Ponds Plume systems are designed to passively intercept and treat contaminated groundwater in low-flow, low-permeability hydrogeologic regimes. These collection/treatment systems are low-maintenance/low-profile systems that are designed for long-term treatment. The PU&D Treatability Study evaluates an *in situ* process to treat contaminants within the plume source area rather than capturing a plume front.

The contaminated groundwater plumes in which the three passive collection and treatment systems and the treatability study were deployed are evaluated in a *Draft Interim Measure/Interim Remedial Action for Groundwater at the Rocky Flats Environmental Technology Site* (Groundwater IM/IRA) (DOE, 2004c). The Groundwater IM/IRA is subject to public review and comment and approval by the Colorado Department of Public Health and Environment (CDPHE) and the Environmental Protection Agency, Region VIII (EPA) after consideration of comments and incorporation of any required changes. The Groundwater IM/IRA proposes additional RFCA accelerated actions to address groundwater contamination for areas of these plumes that are not being intercepted and treated.

## 2.0 MOUND SITE PLUME TREATMENT SYSTEM

The Mound Site Plume Treatment System was installed in 1998 pursuant to the *Final Mound Site Plume Decision Document: A Major Modification to the Final Surface Water Interim Measures/Interim Remedial Action Plan/Environmental Assessment and Decision Document for South Walnut Creek* (Mound Site Plume Decision Document) (DOE, 1997a). System installation is documented in the *Final Mound Site Completion Report* (DOE, 1999a).

The Mound Plume Treatment System collects and treats contaminated groundwater from the Mound Site and Oil Burn Pit #2 area. Contaminated soil was removed from the Mound Site in 1997 in accordance with the *Final Proposed Action Memorandum for the Source Removal at the Mound Site, IHSS 113* (DOE, 1997b). Installation of the 220-foot-long collection system and two treatment cells containing reactive iron was completed in 1998 (Figure 1). Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery that was designed to overflow to the surface when the surrounding soils are saturated. Overflow discharges to the surface immediately downgradient of the treatment cell near South Walnut Creek.

### 2.1 Decision Document Objectives

As stated in the Mound Site Plume Decision Document, the objectives for this project were to:

1. Intercept and treat contaminated groundwater, including seep SW059, at the distal end of the Mound Site Plume.
2. Design and install a passive groundwater treatment system that, to the extent practicable, protects surface water and reduces the contaminant mass loading in surface water consistent with the Action Level Framework (ALF).
3. Design the reactive metals treatment system and the barrier wall construction method to minimize the generation of low-level mixed waste and/or low-level waste.

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4. Design the reactive metals treatment system for easy access for operation and maintenance and for ease in media replacement or final removal.
5. Develop cost and performance data for design of low cost and effective treatment systems.
6. Minimize the impacts to the Preble's Meadow Jumping Mouse during construction by installing silt fences between the construction area and the creek to prevent downstream sedimentation of habitat.
7. Avoid depletion of waters to South Walnut Creek.

This report describes how objectives 1 and 2 are met. It also provides information related to objective 5. The other objectives were met during design and construction and are not specifically evaluated in this report.

## 2.2 Treatment Performance, Monitoring and Maintenance

The monitoring locations and frequency to assess system performance required by the Mound Site Plume Decision Document are shown in Table 2.

**Table 2. Monitoring Requirements for the Mound Plume**

| Task | Month 1 | Months 2-6 | Months 7-12 | Subsequent Years |
|---|---|---|---|---|
| Treatment System Influent (R1I) | Monthly | Monthly | Monthly | Not required |
| Treatment System Effluent (R2E) | Weekly | Monthly | Quarterly | Semi-Annually |
| Downgradient Water Quality – Well 3586 | Quarterly | Quarterly | Quarterly | Semi-Annually |
| Hydraulic Head-water level measurements | Weekly | Monthly | Quarterly | Semi-Annually |

Note: Water levels were also taken for each sampling event. While influent samples were not required after 12 months, influent samples were taken at same time as effluent samples in 2003.

### 2.2.1 Treatment Performance

Installation of this system has eliminated the discharge at Seep SW059. Groundwater that previously discharged at the seep is now collected and treated by the Mound Plume System.

For the period January 1, 2003 through December 29, 2003, 82,000 gallons of contaminated water were treated. The total volume of groundwater treated as of December 29, 2003 was approximately 915,000 gallons. Measured flow rates ranged from no measurable flow for most dates starting from the end of August through mid-December, to a high flow rate of 3.67 gallons per minute (gpm) on March 26. Monthly average flow rates ranged from 0.0 to 0.436 gpm.

The treatment system effectiveness is determined by comparison of the influent and effluent contaminant concentrations. As shown in Table 3, the treatment system is effectively removing VOCs and radionuclides and the effluent meets surface water standards. The principal organic contaminants entering the treatment system are tetrachloroethene, trichloroethene, carbon tetrachloride, and their degradation products. A number of additional compounds are found in trace concentrations including carbon disulfide and benzene. Uranium isotopes are present in

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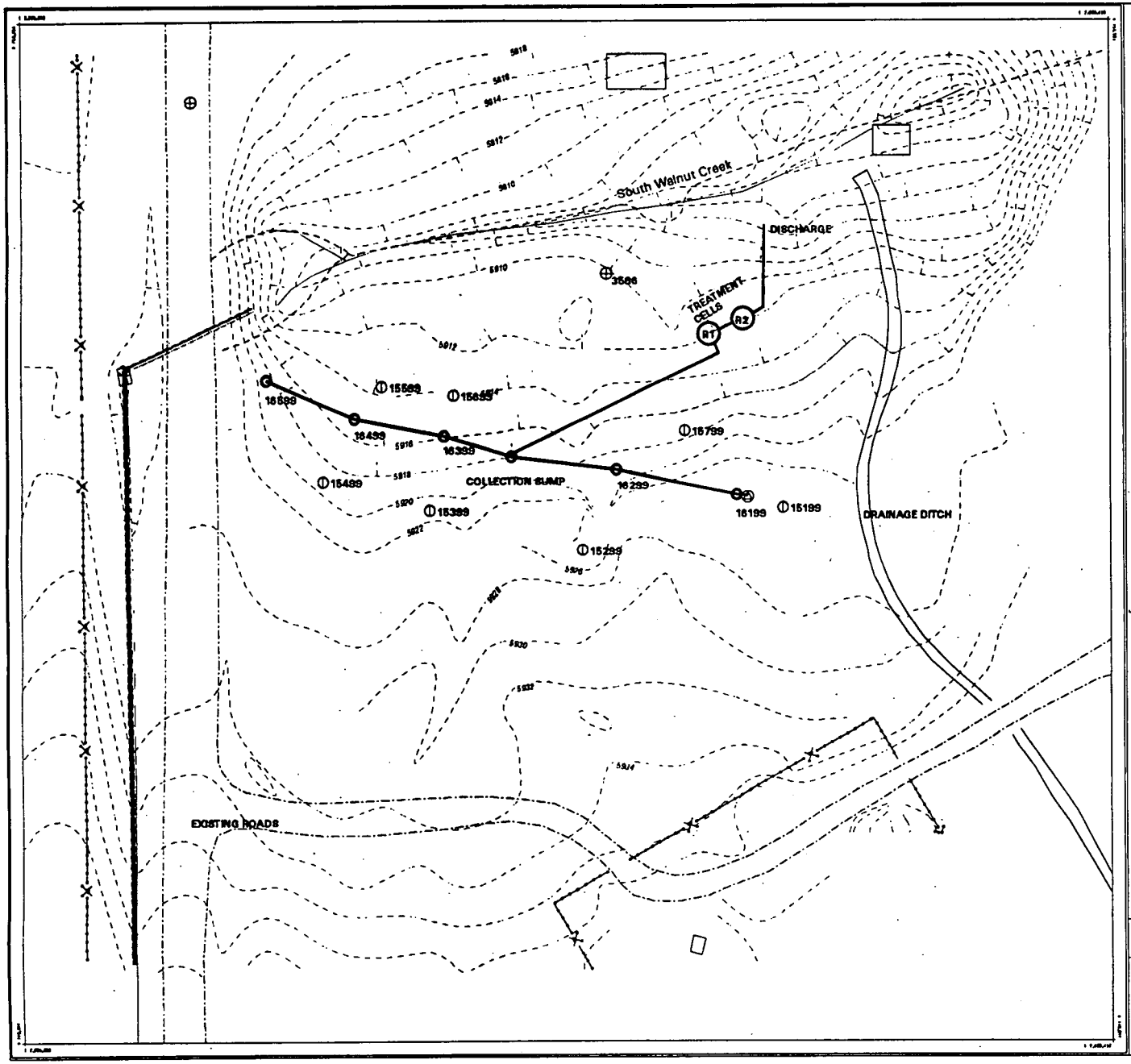


# Figure 1
## Mound Plume Treatment System Locations
### Rocky Flats Environmental Technology Site

**EXPLANATION**

- New Ground Water Well
- Existing Ground Water Well
- New Trench Water-Level Monitoring Probes
- New Trench Cleanout
- Contours
- Fences
- 72" Culvert
- Trench System

**Standard Map Features**

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Paved roads
- Dirt roads

*DATA SOURCE BASE FEATURES:*
*Source for all Detailed Key layers except the new groundwater wells is the smallsat Technology Corporation (ITT) prepared for MSE Technology Applications, Inc in Butte, Montana.*

*Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95*

Scale = 1 : 800
1 inch represents approximately 67 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: CH2MHILL

Prepared for: KH ALLIED TECHNOLOGY GROUP

March 25, 2003

N:_Svr w:/projects/fy2003/03-0341/mound_plume_fig1.aml

the influent but are removed below detection limits in the effluent. Americium-241 and Plutonium-239, 240 were not detected in any samples.[1]

**Table 3. Summary of Mound Site Plume 2003 Sampling Events**

| Contaminant | Influent Concentrations | Effluent Concentrations | RFCA Tier II Groundwater AL | RFCA Surface Water AL | Unit |
|---|---|---|---|---|---|
| Benzene | ND | ND-0.25 | 5 | 1.2 (5)† | ug/l |
| Carbon Tetrachloride | 73-104D | ND | 5 | 0.25 (5)† | ug/l |
| Carbon Disulfide | ND-0.44J | ND | 3,650 | 3.65 | ug/l |
| Cis 1,2-Dichloroethene | 9-23 | 1-4.4 | 70 | 70 | ug/l |
| Chloroform | 19-21.4 | ND-0.93J | 100 | 5.7 | ug/l |
| 1,1-Dichloroethane | ND-1 | ND-1 | 3,650 | 3.65 | ug/l |
| 1,2-Dichloroethane | ND-0.39J | ND-0.31J | 5 | 0.4 (5)† | ug/l |
| 1,1-Dichloroethene | 0.39J-2 | ND-0.23J | 7 | 0.057 (7)† | ug/l |
| Methylene Chloride | ND | 3.5B | 5 | 4.7 | ug/l |
| Tetrachloroethene | 22.6-31 | ND-0.38J | 5 | 0.8 (5)† | ug/l |
| 1,1,1-Trichloroethane | 2-2.8 | ND | 200 | 200 | ug/l |
| Trichloroethene | 31.4-38 | ND-0.31J | 5 | 2.7 (5)† | ug/l |
| Vinyl Chloride | ND-0.81J | ND | 2 | 2 | ug/l |
| Americium-241 | ND | ND | 0.145 | 0.15 | pCi/l |
| Plutonium-239,240 | ND | ND | 0.151 | 0.15 | pCi/l |
| Uranium-233, 234 | 3.16-6.16 | ND | 1.06 | 10* | pCi/l |
| Uranium-235 | ND-0.371J | ND | 1.01 | 10* | pCi/l |
| Uranium-238 | 2.27-3.84 | ND | 0.768 | 10* | pCi/l |

D - diluted
J - detected at concentrations below the required detection limit
ND - not detected at the detection limit for this analysis
ug/l - micrograms per liter
pCi/l - picoCuries per liter
* - standard provided is for total uranium
† - Parenthetical values are the temporary modifications in effect through 2009

The approximate contaminant mass removed is shown in Table 4 and was calculated based on the total measured flow and the midpoint of the contaminant concentration range from Table 3. Mass removed is reported as grams (g) or microCuries (uCi). Previous years are included for comparison. Volumes in 1999/2000 represent two years of water treatment. These are approximate volumes because of problems with the flow meter. However, these values represent the appropriate order of magnitude volumes. Volumes are higher because of higher precipitation during this timeframe.

[1] Note that RFCA groundwater ALs for these radionuclides are being updated because EPA has published changes to their respective cancer slope factors. The updated values are: Am-241 = 0.458; Pu-239/240 = 0.353; U-233/234 = 0.663; U-235 = 0.684; and, U-238 = 0.744 pCi/l.

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## Table 4. Approximate Contaminant Mass Removed at Mound Site Plume System

| Contaminant | Influent (ug/l) | Effluent (ug/l) | Removed conc. (ug/l) | Volume Treated (l) | Total Mass Removed (g or uCi) |
|---|---|---|---|---|---|
| **Calendar Year 2003** | | | | | |
| Carbon Tetrachloride | 88.5 | ND | 88.5 | 310,400 | 27.5 |
| Tetrachloroethene | 26.8 | 0.19 | 26.6 | 310,400 | 8.3 |
| Trichloroethene | 34.7 | 0.16 | 34.5 | 310,400 | 10.7 |
| Total Uranium* pCi/l | 8.0 | ND | 8.0 | 310,400 | 2.5 |
| **Calendar Year 2002** | | | | | |
| Carbon Tetrachloride | 120.0 | ND | 120.0 | 200,600 | 24.1 |
| Tetrachloroethene | 37.3 | ND | 37.3 | 200,600 | 7.5 |
| Trichloroethene | 61.4 | ND | 61.4 | 200,600 | 12.3 |
| Total Uranium** pCi/l | 7.21 | ND | 7.2 | 200,600 | 1.4 |
| **Calendar Year 2001** | | | | | |
| Carbon Tetrachloride | 101.5 | ND | 101.5 | 450,000 | 45.7 |
| Tetrachloroethene | 47.0 | ND | 47.0 | 450,000 | 21.2 |
| Trichloroethene | 75.0 | ND | 75.0 | 450,000 | 33.8 |
| Total Uranium* pCi/l | 15.0 | 0.19 | 14.8 | 450,000 | 6.7 |
| **Calendar Year 1999/2000** | | | | | |
| Carbon Tetrachloride | 92.0 | ND | 92.0 | 2,503,800 | 230.3 |
| Tetrachloroethene | 86.5 | 1.00 | 85.5 | 2,503,800 | 214.1 |
| Trichloroethene | 113.5 | 0.85 | 112.7 | 2,503,800 | 282.1 |
| Total Uranium* pCi/l | 6.5 | ND | 6.5 | 2,503,800 | 16.3 |

* Avg. U-233, -234 + Avg.U-235 + avg. U-238
** U Isotopic data not broken out in 2002 Report

### 2.2.2 Groundwater Monitoring

Well locations are shown on Figure 1. Downgradient water quality is monitored at Well 3586 to determine the ability of the groundwater collection system to limit plume expansion and to mitigate potential increases in plume contaminant concentrations at this location. Well 3586 is the Mound Site Plume Decision Document designated performance monitoring well. Sampling results for other downgradient groundwater wells in this area also provide information on the barrier performance and are reported below. The groundwater quality monitoring results for certain wells upgradient of the barrier are also included to allow comparison with treatment cell influent concentrations and to monitor for possible changes in groundwater flows and contaminant concentrations due to the barrier. The sampling regime for these other groundwater monitoring wells is specified in the Integrated Monitoring Plan for 2003 (IMP) (DOE 2003)

Water levels (hydraulic head) upgradient and downgradient of the collection system are compared as another indicator of the installed barrier's ability to intercept and collect groundwater in this area.

#### 2.2.2.1 Upgradient Water Quality

The closest wells upgradient of the Mound treatment system had relatively low concentrations of VOCs in 2003. The highest VOC concentrations in Well 15399 were 72.2 micrograms per liter

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(ug/l) of cis-1,2- dichloroethene and 106 ug/l of trichloroethene. Well 15499 had 107 ug/l of trichloroethene and 118 ug/l of tetrachloroethene.

Two upgradient wells, 91103 and 91203, were recently installed in the area of soil contamination associated with IHSS 153, the Oil Burn Pit #2. Groundwater in Well 91203 had relatively low concentrations of VOCs; the highest concentration being carbon tetrachloride at 126 ug/l. Well 91103, which is located within the source area had groundwater VOC concentrations two orders of magnitude higher than other upgradient wells. Tetrachloroethene in this well was 18,100 ug/l and trichloroethene was 10,800 ug/l. Contaminant concentrations decline closer to the collection system and the influent concentrations do not reflect these higher contaminant concentrations.

### 2.2.2.2 Downgradient Water Quality

The collection system was installed near South Walnut Creek "to capture the contaminated groundwater to the extent practicable." Wells downgradient of the collection system are located within the portion of the plume that was not targeted for treatment.

Three wells in addition to well 3586 were planned for sampling in accordance with the IMP. However, during 2003, Well 15799 did not contain sufficient water for sampling and Wells 15599 and 15699 had sufficient water only for one sampling event during the year. Radionuclides and VOCs were sampled on different dates in Well 15699 during the same springtime sampling event. Analytical results from these wells are provided in Table 5.

**Table 5. Downgradient Well Analytical Results**

| Analyte | Performance Monitoring Well 3586 | | Well 15599 | Well 15699 | | RFCA GW Tier II AL | Units |
|---|---|---|---|---|---|---|---|
| | 4/21/03 | 11/20/03 | 4/22/03 | 4/23/03 | 5/16/03 | | |
| Benzene | ND | 0.54J | ND | ND | - | 5 | ug/l |
| Chloroform | ND | ND | 0.69J | ND | - | 100 | ug/l |
| 1,1-Dichloroethane | ND | 12.4 | ND | ND | - | 3650 | ug/l |
| 1,2-Dichloroethane | ND | 0.34J | ND | ND | - | 5 | ug/l |
| cis-1,2-Dichloroethene | ND | 3.2 | 0.85J | 26 | - | 70 | ug/l |
| trans-1,2-Dichloroethene | ND | 0.43J | ND | ND | - | 70 | ug/l |
| Tetrachloroethene | ND | ND | 16.5 | 24 | - | 5 | ug/l |
| Trichloroethene | ND | ND | 21.1 | 37 | - | 5 | ug/l |
| Vinyl Chloride | ND | 2.9 | ND | ND | - | 2 | ug/l |
| Uranium-233,234 | 1.82 | 1.52 | 4.97 | - | 16.6 | 1.06 | pCi/l |
| Uranium-235 | ND | 0.33 J | 0.696J | - | 0.544 | 1.01 | pCi/l |
| Uranium-238 | 1.28 | 1.29 | 3.31 | - | 13.4 | 0.768 | pCi/l |

- =Not sampled
J = detected at concentrations below the detection limit for this analysis
ND = not detected at the detection limit for this analysis

Figures 2 and 3 show the concentration trends for the downgradient wells. Because of the variation in downgradient concentrations, continued IMP monitoring is anticipated to confirm that concentrations are being reduced.

Cis 1,2 dichloroethene and vinyl chloride are degradation products of the primary groundwater contaminants in this plume. The low concentrations seen in the downgradient wells are probably

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a result of the residual, pre-existing plume and generally not a byproduct of the treatment process. The treatment system is effective in removing uranium. Any uranium in the downgradient wells is a result of residual contamination or naturally occurring uranium.

**Figure 2. Mound Site Plume Downgradient Trichloroethene Concentrations**

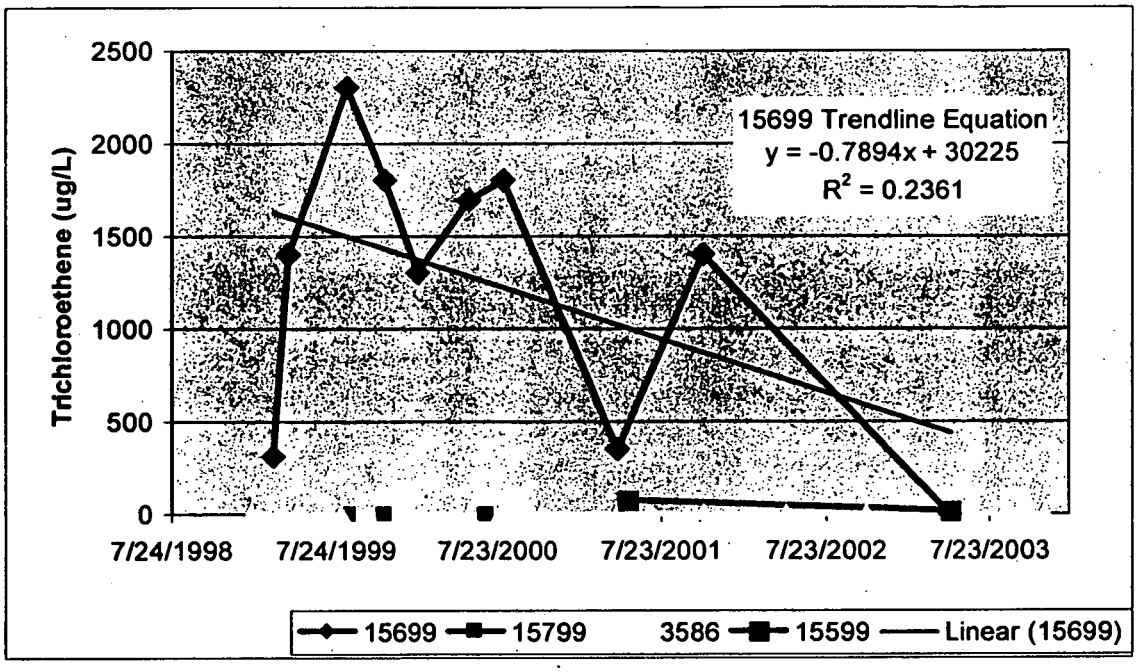
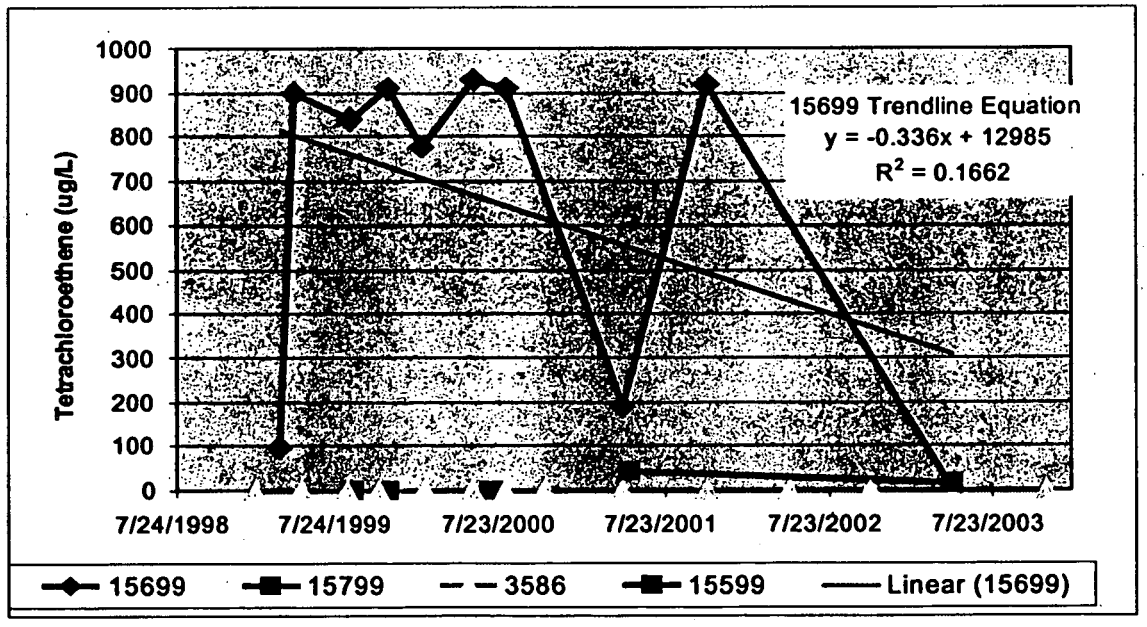



**Figure 3. Mound Site Plume Downgradient Tetrachloroethene Concentrations**



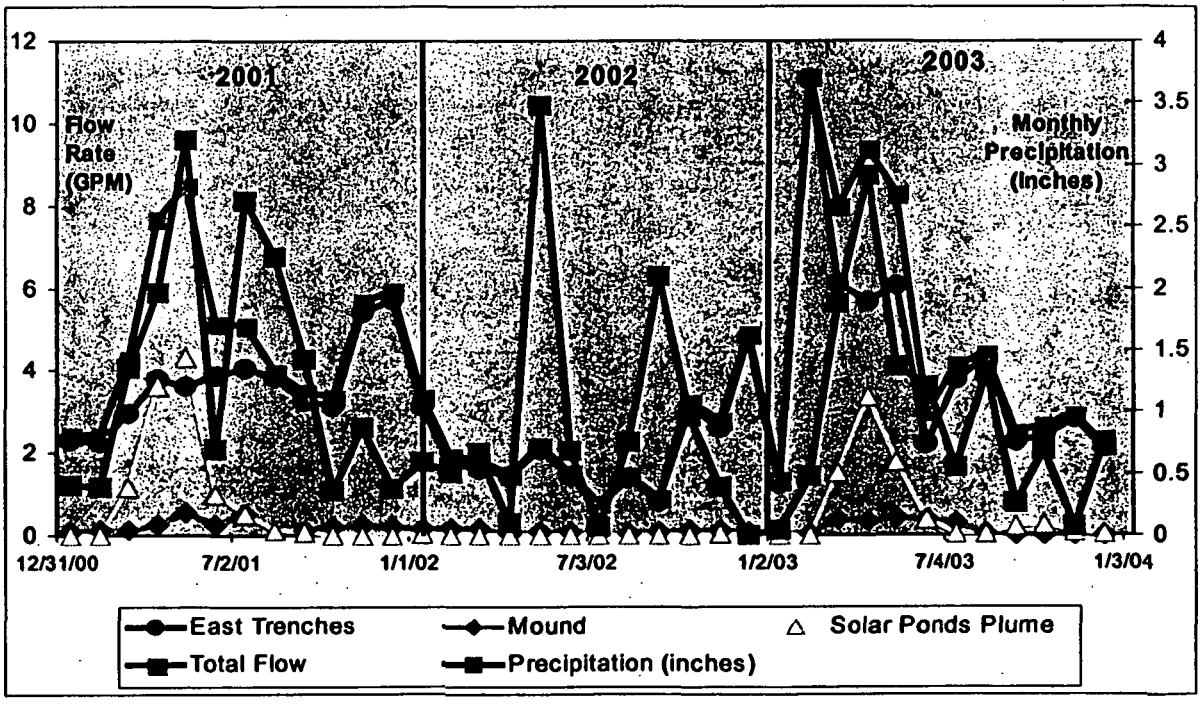

Concentrations in the downgradient wells indicate that the residual contamination levels are declining and that the collection system tends to mitigate downgradient plume concentrations. For example, concentrations at Well 15599, frequently dry in the past, have decreased since the previous sample collected in 2001. Well 3586 continued to have low concentrations as it has

had in the past. A decrease in trichloroethene concentrations was noted in Well 15699. Tetrachloroethene concentrations are more variable, and the downward trend is not as evident. This well is located within the preferential flow path for the Mound Site Plume and along the trend of the highest plume concentrations defined in the pre-remedial investigation (DOE 1997a).

### 2.2.2.3 Water Levels

Groundwater levels are used to indicate the hydraulic head within and adjacent to the collection and treatment system. Five piezometers (16199 through 16599) were monitored quarterly within the collection trench (Figure 1). The piezometer at the east end of the collection trench (Piezometer 16199) was dry throughout the year, as it has been in the past. The water levels in the other piezometers were fairly consistent except in April when the groundwater elevations in the other four piezometers were about a foot higher than previously recorded observations. This is likely due to the heavy precipitation at the end of March that also corresponded to increased flow rates within the treatment systems. Groundwater elevations in the nearby wells were also elevated as discussed below.

**Figure 4. Monthly Precipitation vs Average Monthly Flow Rates for Mound Site Plume, East Trenches Plume and Solar Ponds Plume Treatment Systems**




Groundwater levels were monitored quarterly at seven locations surrounding the collection trench (three upgradient, three downgradient, and one to the east) as shown in Figure 1 and Table 6. Groundwater elevations in the wells upgradient of the collection trench still show drought effects in January but subsequently increased about three feet in 15399 and more than eight feet in 15499. Well 15299 has remained dry and indicating that there is probably less upgradient flow to the treatment system on the east side.

The groundwater elevations in wells downgradient of the trench appear to have recovered from the drought. Seasonal water level fluctuations are approximately two to seven feet in upgradient

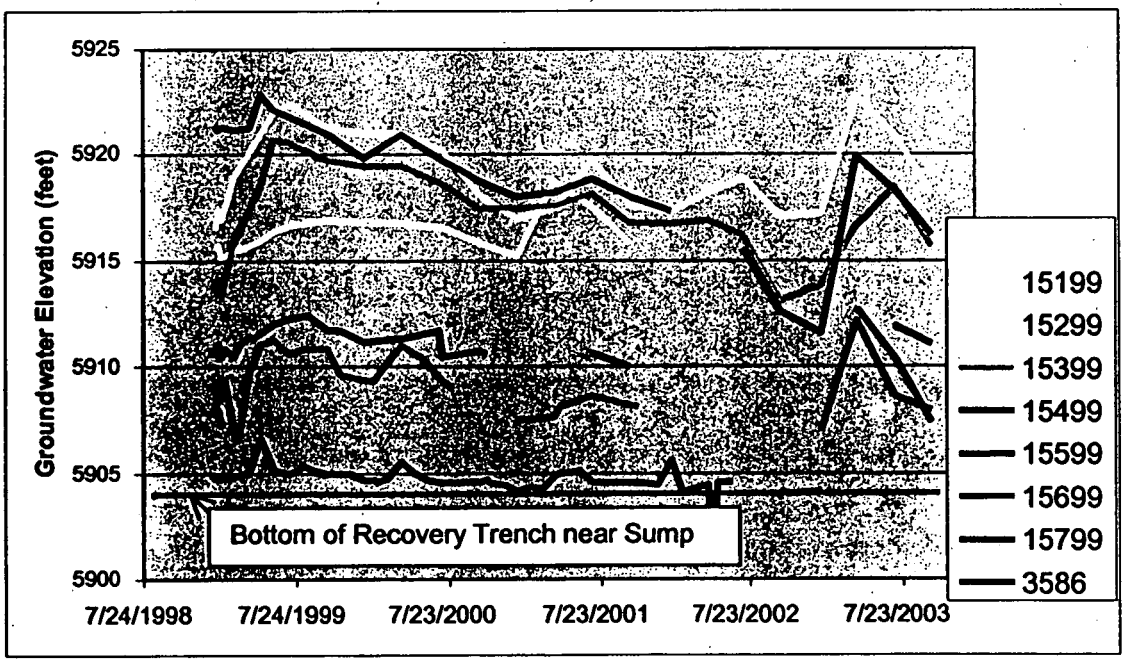
and downgradient wells. Seasonal fluctuations were higher this year due to drought conditions in beginning of year followed by a heavy snowstorm in March. Groundwater elevations in Well 3586, near South Walnut Creek, remained within a few feet of the normal creek elevation of 5,903 feet in this area.

**Table 6. Mound Site Plume Upgradient and Downgradient Water Elevations (Feet Above MSL)**

| Well Number | Location | 01/08/03 | 04/08/03 | 07/02/03 | 10/02/03 |
|---|---|---|---|---|---|
| 15199 | Eastern | 5917.28 | 5922.76 | 5920.86 | 5918.21 |
| 15299 | Upgradient | Dry | Dry | Dry | Dry |
| 15399 | Upgradient | 5913.86 | 5916.68 | 5918.55 | 5915.71 |
| 15499 | Upgradient | 5911.58 | 5919.91 | 5918.38 | 5916.26 |
| 15599 | Downgradient | Dry | 5912.79 | 5910.46 | 5907.43 |
| 15699 | Downgradient | 5906.99 | 5912.24 | 5908.66 | 5908.03 |
| 15799 | Downgradient | Dry | Dry | 5911.92 | 5911.08 |

Water elevations are shown graphically in Figure 5. A simplified conceptual model of groundwater flow near the collection trench is shown on Figure 6. The hydraulic gradient induced by the trench can be seen in the difference in water elevations driving the water from the edges of the capture area, toward the center of the downgradient portion of the plume.

**Figure 5. Mound Site Plume Water Elevations in Wells versus Time**




**Note:** Elevation of the collection trench base is 5905 to 5914

In January 2003, drought conditions greatly reduced the groundwater flow. As a result, the two outside downgradient wells, 15599 and 15799, were dry and the water level at 15699 was greatly reduced.

After the March precipitation event, a measurable water level was re-established at Well 15599 on the west side but not at 15799. The increase in water levels was likely a result of the heavy

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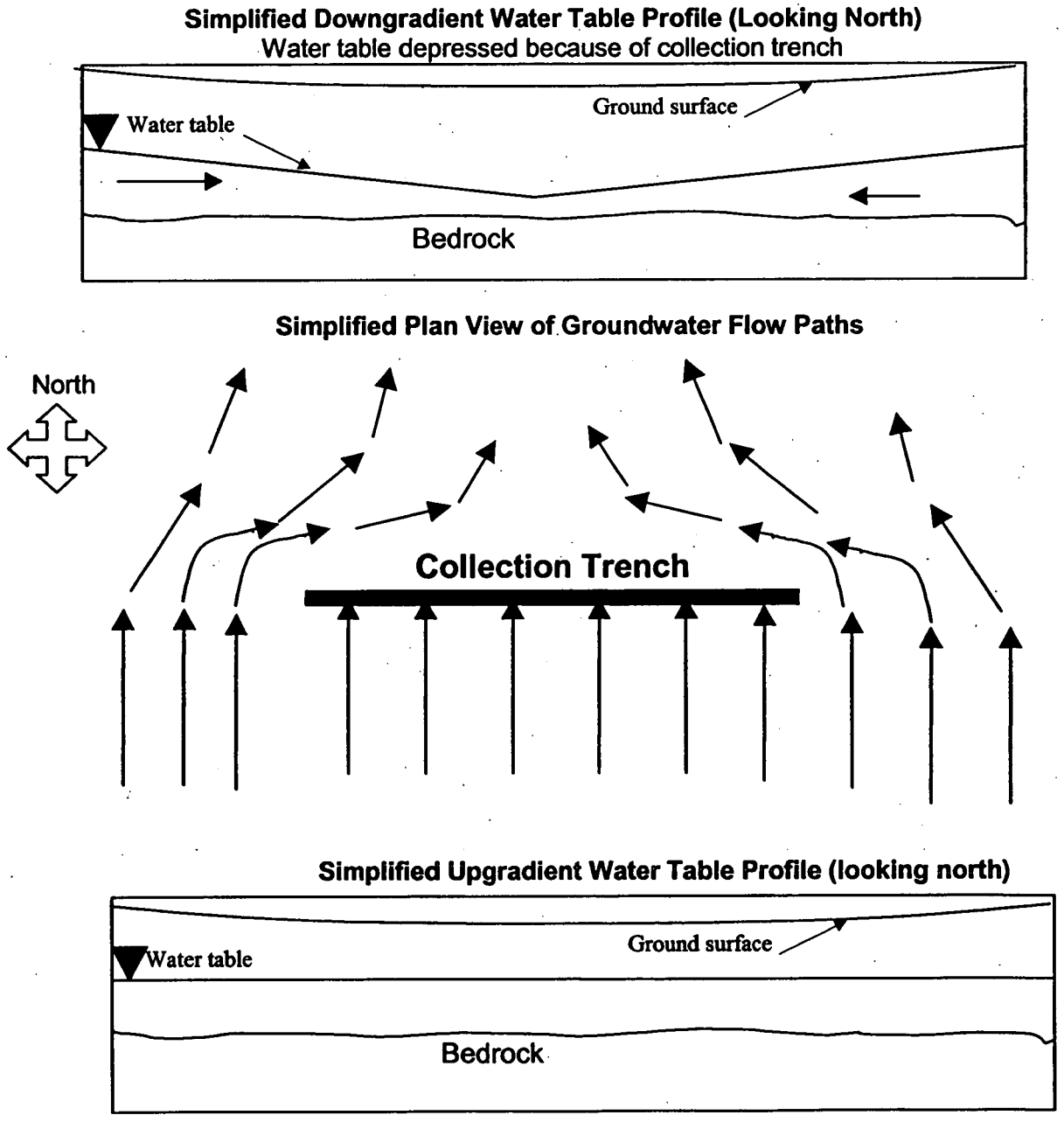
snow pack melting above these areas and percolating downwards into the groundwater. The slope on the east side of the collection trench is flatter and may have allowed for more percolation into the soil. On the steeper sloped, west side of the collection trench, snowmelt is more likely to become run-off. By July, the downgradient groundwater profile returned to normal conditions that are illustrated on Figure 6. This is consistent with the intended design and indicates that the collection system is working effectively.

**Figure 6. Conceptual Model of Groundwater Flow near the Mound Site Plume Collection Trench**



## 2.3 Operations and Maintenance

During 2003, system maintenance included raking the media in the treatment cells and system checks periodically over the course of the year. Media raking has been reduced because the crust formation continues to be minimal. The flow measurement flume was cleaned about three times and recalibrated five times. Site personnel performed quarterly water level monitoring and semiannual analytical sample collection, in accordance with Table 2 of the Mound Site Plume Decision Document.

The ongoing treatment system maintenance, raking the iron media, retrieving flow rate and water level data, flow meter maintenance and calibration, and monitoring water quality, are the only necessary operational activities. A more frequent maintenance schedule is planned in 2004 for the flow meter because of the recent plugging problems. Both the treatment system and downgradient wells will continue to be sampled on a semiannual basis, and water levels will be measured quarterly.

As discussed in the Mound Site Plume Decision Document, the media is anticipated to require replacement every 5 to 10 years. Based on performance to date, media replacement is anticipated to occur in 2008, after approximately 10 years in service.

## 2.4 Conclusions

The Mound Site Plume Treatment System is operating properly and successfully. The effectiveness of the Mound Site Plume Treatment System was evaluated by comparing the Mound Site Plume Decision Document remedial action objectives to the system performance. These objectives are:

1. Intercept and treat contaminated groundwater, including seep SW059, at the distal end of the Mound Site Plume. Evaluated as collection system effectiveness (Section 2.4.1).
2. Design and install a passive groundwater treatment system that, to the extent practicable, protects surface water and reduces the contaminant mass loading in surface water consistent with the ALF. Evaluated as treatment system effectiveness (Section 2.4.2).

In addition, operation and maintenance information from approximately five years of operation, described in section 2.3 is provided to allow further evaluation of overall effectiveness of this type of system for specific applications at RFETS.

### 2.4.1 Collection System Effectiveness

During construction, groundwater exiting at Seep SW059 was intercepted. This water is now captured by the Mound Site Plume Treatment System collection trench and treated along with contaminated groundwater captured from the plume. The collection trench continues to be effective in cutting off and recovering significant volumes of contaminated groundwater. In 2003, approximately 82,000 gallons of contaminated groundwater were captured and treated. This volume is consistent with annual quantities collected and treated since installation.

Performance monitoring well 3586 results continue to show groundwater contaminant concentrations for some detected VOCs and for some uranium isotopes are above RFCA Tier II Action Levels downgradient of the Mound Site Plume Treatment System. These appear to be from residual contamination and naturally occurring uranium rather than from contamination that has bypassed the collection system. It is likely that concentrations in these areas are decreasing due to degradation and flushing by cleaner groundwater that is not captured by the collection

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trench. The downgradient plume area was evaluated as part of the Draft Groundwater IM/IRA (DOE, 2004c) and no additional accelerated action is required for this area.

Upgradient concentrations are not significantly reduced from levels observed prior to system installation, so the system continues to serve the function of intercepting contaminated groundwater. Therefore objective 1 is being met.

### 2.4.2 Treatment System Effectiveness

The Mound Site Plume Treatment System is effectively reducing the mass loading to surface water. Approximately 47 grams of VOC contamination were removed by the treatment system during 2003, which appears consistent with removal rates in previous years. Effluent concentrations meet RFCA surface water action levels and standards. Therefore objective 2 is being met.

## 2.5 Planned Activities

Continued raking of the media, sampling and water level measures are planned for this system. It does not appear at this time that the media is losing any treatment capacity, with perhaps several more years before replacement is needed. The Operations and Maintenance Manual will be updated to reflect current conditions for all of the treatment systems.

# 3.0 EAST TRENCHES PLUME TREATMENT SYSTEM

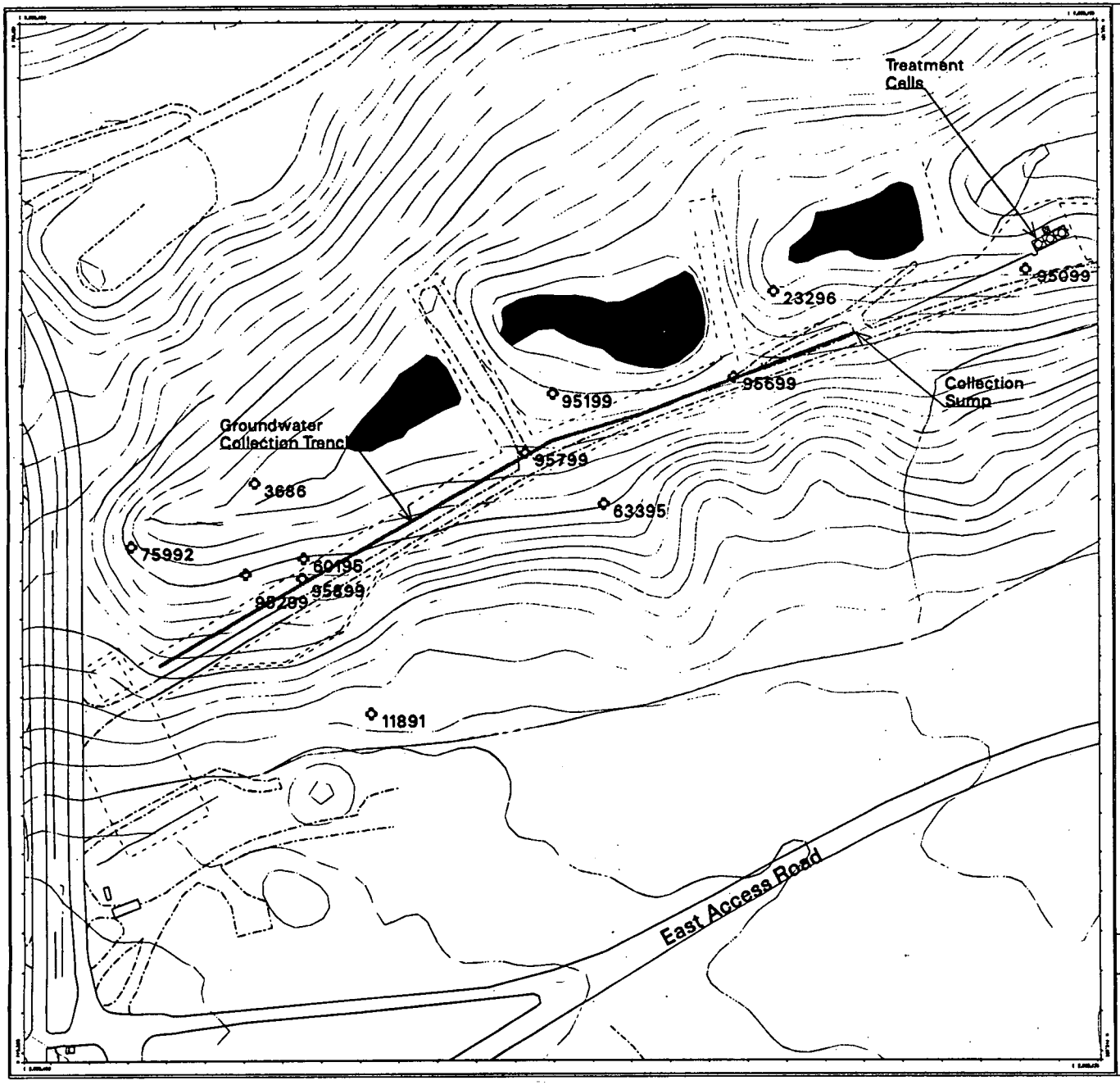
The East Trenches Plume Treatment System was installed in 1999 pursuant to the *Final Proposed Action Memorandum for the East Trenches Plume* (East Trenches Plume PAM) (DOE, 1999b). System installation is documented in the *Final East Trenches Plume Project Closeout Report, Fiscal Year 1999* (DOE, 2000a).

The East Trenches Plume Treatment System collects and treats contaminated groundwater emanating from the area around Trench 3 and Trench 4. These trenches were the primary sources for the contaminated groundwater plume and were remediated in 1996 as an RFCA accelerated action, in accordance with the *Final Proposed Action Memorandum for the Source Removal at Trenches T-3 and T-4, IHSSs 110 and 111.1* (DOE, 1996b). Installation of the 1,200-foot-long collection system, and two reactive iron treatment cells, similar to the Mound Site Plume Treatment System, was completed in September 1999. Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery that was designed to overflow to the surface when the surrounding soils are saturated. This overflow discharges to the surface immediately downgradient of the treatment cell near South Walnut Creek. Locations are shown in Figure 7.

## 3.1 Decision Document Objectives

Pursuant to the East Trenches Plume PAM, The objectives for the East Trenches Plume Treatment System were to:

1. Intercept and treat VOC-contaminated groundwater at the distal end of the East Trenches Plume.
2. Protect surface water and reduce the VOC-contaminant mass loading in surface water, to the extent practicable.




# Figure 7
## East Trenches Plume Treatment System Locations

**EXPLANATION**

- Surface Water Drainage
- Collection Trench
- Monitoring Well

**Standard Map Features**

- Buildings and other structures
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (5-Foot)
- Paved roads
- Dirt roads

*DATA SOURCE BASE FEATURES:*
*Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95*
*Topographic contours were derived from digital elevation model (DEM) data by Montrose Envirodata (MID) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.*

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Scale = 1 : 2740
1 inch represents approximately 228 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

CSS Dept. 303-689-7707

Prepared by: CH2MHILL

Prepared for: KAISER-HILL

March 25, 2003

NT_Svr w:/projects/fy2003/03-0341/east_trench_fig7.aml

3. Install an easily accessible system to reduce operation and maintenance costs and to easily replace media when necessary.
4. Minimize the impact to Preble's Meadow Jumping Mouse during construction.
5. Avoid depletion of waters to South Walnut Creek.

This report describes how objectives 1 and 2 are met. It also provides information related to Objective 3. The other objectives were met during design and construction and are not specifically evaluated in this report.

## 3.2 Treatment Performance, Monitoring and Maintenance

The monitoring locations and frequency to assess system performance required by the East Trenches Plume PAM are shown in Table 7.

**Table 7 – East Trenches Plume Treatment System Monitoring Requirements**

| Task | Month 1 | Months 2-6 | Months 7-12 | Subsequent Years |
|---|---|---|---|---|
| Treatment System Influent | Monthly | Monthly | Monthly | Semi-Annually |
| Treatment System Effluent | Monthly | Monthly | Quarterly | Semi-Annually |
| Downgradient Water Quality | Quarterly | Quarterly | Quarterly | Semi-Annually |
| Hydraulic Head-water level measurements | Monthly | Monthly | Quarterly | Semi-Annually |

### 3.2.1 Treatment Performance

For the period January 1, 2003 through December 29, 2003, approximately 2.1 million gallons of groundwater was treated by the system. The total volume of groundwater treated as of December 29, 2003 was approximately 7.8 million gallons. Daily average flow rates ranged from 0.03 to 18.10 gpm, and averaged 4.23 gpm. As occurred at the Mound Plume Treatment System, the high flow rates correlate with periods of precipitation. However, as described in Section 3.2.4, the high flow rate in February 2003 was most likely a result of water backing up in the flume from plugged discharge piping, causing a false, higher reading.

The treatment system effectiveness is determined by comparison of the influent and effluent contaminant concentrations. A summary of these sampling events is provided in Table 8. The contaminants of concern for this plume are primarily trichloroethene, tetrachloroethene and carbon tetrachloride. However, other contaminants are detected at lower concentrations. As shown in Table 8, the treatment system is effectively removing VOCs. However, the surface water standards for tetrachloroethene, trichloroethene and methylene chloride were not met consistently during this calendar year.

Based on bench scale tests conducted prior to system installation, methylene chloride is not effectively removed by this treatment system (DOE, 1999b). The exceedances for tetrachloroethene and trichloroethene are the result of the system plugging as discussed in the Operations and Maintenance section.

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## Table 8. Summary of East Trenches Plume 2003 Sample Results

| Compound | Influent Concentration (ug/l) | | Effluent Concentration (ug/l) | | | RFCA Tier II Ground water AL (ug/l) | RFCA Surface water AL (ug/l) |
|---|---|---|---|---|---|---|---|
| | 4/17/03 | 11/20/03 | 4/17/03 | 9/22/03 | 11/20/03 | | |
| Acetone | ND | ND | ND | ND | 15 | 3,650 | 3,650 |
| Benzene | ND | ND | 0.5 J | 0.4J | 0.22J | 5 | 1.2† |
| 2-Butanone | ND | ND | ND | 5.3J | ND | 21,900 | 21.900 |
| Carbon Tetrachloride | 120 | 160 | ND | ND | ND | 5 | 0.25† |
| Chloroform | 68 | 73 | 7.1 | 7.53 | ND | 100 | 5.7 |
| 1,1-Dichloroethane | ND | ND | 1.5 | 0.82J | 0.41 | 3,650 | 3.65 |
| 1,1-Dichloroethene | 3.9J | 5J | 1.6 | 1.4J | 0.24J | 7 | 7† |
| Methylene Chloride | ND | ND | 6.4B | 11.7 | 17 | 5 | 4.7 |
| Tetrachloroethene | 290 | 380 | 19 | 57.3 | 1.3 | 5 | 5† |
| Toluene | ND | ND | 0.23J | ND | 2.23 | 1,000 | 1,000 |
| 1,1,1-Trichloroethane | 4.3J | 4.7J | ND | ND | ND | 200 | 200 |
| Trichloroethene | 2000* | 2700* | 60 | 77.4 | 5.7 | 5 | 5† |

J = detected at concentrations below the detection limit for this analysis
ND = not detected at the detection limit for this analysis
* = Concentration exceeds RFCA Tier I Groundwater AL
† = temporary modifications in effect through 2009

The approximate contaminant mass removed is shown in Table 9 and was calculated based on the total measured flow and the midpoint of the contaminant concentration range from Table 8. Previous years are included for comparison. The table shows that reduction in mass loading to the stream is being achieved (remedial objective 2). The system was installed in 1999 and about 21,000 grams per year of VOCs are removed.

## Table 9. East Trenches Plume System Approximate Contaminant Mass Removed

| Contaminant | Influent (ug/l) | Effluent (ug/l) | Removed conc.(ug/l) | Volume Treated (l) | Total Mass Removed (g) |
|---|---|---|---|---|---|
| **Calendar Year 2003** | | | | | |
| Carbon Tetrachloride | 140 | ND | 140.0 | 7,949,400 | 1,112.9 |
| Tetrachloroethene | 335 | 29.15 | 305.9 | 7,949,400 | 2,431.3 |
| Trichloroethene | 2,350 | 41.55 | 2,308.5 | 7,949,400 | 18,350.8 |
| **Calendar Year 2002** | | | | | |
| Carbon Tetrachloride | 176 | ND | 175.5 | 3,785,400 | 664.3 |
| Tetrachloroethene | 324 | 6.73 | 316.8 | 3,785,400 | 1,199.1 |
| Trichloroethene | 2,540 | 2.46 | 2,537.5 | 3,785,400 | 9,605.6 |
| **Calendar Year 2001** | | | | | |
| Carbon Tetrachloride | 160 | ND | 160.0 | 7,192,300 | 1,150.8 |
| Tetrachloroethene | 300 | 2.95 | 297.1 | 7,192,300 | 2,136.5 |
| Trichloroethene | 2,700 | 0.33 | 2,699.7 | 7,192,300 | 19,416.8 |
| **Calendar Year 1999/2000** | | | | | |
| Carbon Tetrachloride | 185 | - | 185.0 | 10,599,200 | 1,960.9 |
| Tetrachloroethene | 370 | 1.00 | 369.0 | 10,599,200 | 3,911.1 |
| Trichloroethene | 3,600 | 1.00 | 3,599.0 | 10,599,200 | 38,146.5 |

### 3.2.2 Groundwater Monitoring

As required by the East Trenches Plume PAM, four downgradient wells were installed during construction. These wells monitor the ability of the groundwater collection system to control plume expansion and monitor potential increases in plume contaminant concentrations at locations in the plume to determine if mitigating measures were required. These wells are shown on Figure 7 and monitoring results are provided below. The groundwater quality monitoring results for certain wells upgradient of the barrier are also included to allow comparison with treatment cell influent concentrations and to monitor for possible effects of changes in groundwater flows and contaminant concentrations due to the barrier. The sampling regime for these other groundwater monitoring wells is specified in the Integrated Monitoring Plan for 2003 (IMP) (DOE 2003).

#### 3.2.2.1 Upgradient Water Quality

Wells 11891 and 95503 are located upgradient of the collection and treatment system. In 2003, the contaminants in Well 11891 were carbon tetrachloride at 196 to 447 ug/l, tetrachloroethene at 131 to 193 ug/l, and trichloroethene at 25.3 to 41.4 ug/l. Well 95503 had very low concentrations of carbon tetrachloride (0.76 ug/l). None of the other contaminants found in the treatment system influent were detected in this well.

Carbon tetrachloride and tetrachloroethene concentrations at these upgradient wells are the same order of magnitude as the treatment system influent. Trichloroethene at these well locations appears to be about two orders of magnitude lower than the influent. It appears that the collection barrier intercepts an area of trichloroethene at higher concentrations than indicated by well results. While this mitigates potential impacts from this contamination, it also may tend to lower the expected treatment media life.

Bench scale testing for the design of the treatment system, as described in the East Trenches Plume PAM, was based on a VOC loading of 5.2 grams/day, or about 1,900 grams/year. While the bench scale testing showed that high concentrations of VOCs are effectively treated using this media, the gram loading observed to the treatment system for trichloroethene alone is much higher than 1,900 grams/year.

#### 3.2.2.2 Downgradient Water Quality

Table 10 shows the CDPHE surface water sampling results in Pond B-2, downgradient of the collection system. The Pond B-2 south sample is closest to the collection system (Figure 7).

Grab samples taken in March 2003 from Pond B-2 show significantly higher VOC concentrations than other sampling events. These samples were taken in the winter, and ice on the pond probably reduced volatilization. These results are also much higher than what has been previously observed in adjacent groundwater Well 95199.

Dibromochloromethane was detected in the pond water. It is a disinfectant by-product normally associated with chlorinated water, typically drinking water. Its presence suggests that some of the contamination might have come from a different source other than groundwater; although there is no readily apparent chlorinated water source. Treated sewage is an unlikely source because this pond is isolated from the drainage and did not received effluent from the B995 waste water treatment plant.

Except for the presence of dibromochloromethane and vinyl chloride, both samples taken from Pond B-2 in March 2003 are consistent with what would be expected in groundwater adjacent to the pond. Differences are generally a caused by degradation that is likely occurring in this zone

at a higher rate than in the area of the groundwater wells. However, the presence of vinyl chloride is unusual since it has not been found in surrounding wells. It is present in extremely low concentrations and is probably formed by degradation of dichloroethene. It is not apparent why the vinyl chloride did not further degrade in the pond sediments or become more diluted from the pond water; however, the samples were taken at the edge of the pond where contaminated groundwater is daylighting. It is possible that not much mixing is occurring in this area.

**Table 10. CDPHE Pond B-2 Sampling Results**

| | Pond B-2 North | | | | SURFACE WATER AL (ug/L) |
|---|---|---|---|---|---|
| | 10/22/2002 | 3/5/2003 | 5/29/2003 | 9/24/2003 | |
| Carbon Tetrachloride | nd | nd | nd | nd | 5† |
| Chloroform | nd | 0.9 | nd | nd | 5.7 |
| Dibromochloromethane | nd | 2.5 | nd | nd | 80 |
| 1,1-Dichloroethene | nd | nd | nd | nd | 7† |
| Cis 1,2-Dichloroethene | 1.2 | 6 | 0.8 | 1.1 | 70 |
| Trans 1,2-Dichloroethene | nd | nd | nd | nd | 100 |
| Tetrachloroethene | nd | 2.4 | nd | nd | 5† |
| Trichloroethane | nd | nd | nd | nd | 200 |
| Trichloroethene | nd | 19 | 0.5 | 0.8 | 5† |
| Trihalomethanes | nd | nd | nd | nd | 80 |
| Vinyl Chloride | nd | 0.8 | nd | nd | 2 |
| | Pond B-2 South | | | | |
| | 10/22/2002 | 3/5/2003 | 5/29/2003 | 9/24/2003 | |
| Carbon Tetrachloride | nd | 5.3 | nd | nd | 5† |
| Chloroform | nd | 12 | nd | nd | 5.7 |
| Dibromochloromethane | nd | 2.5 | nd | nd | 80 |
| 1,1-Dichloroethene | nd | nd | nd | nd | 7† |
| Cis 1,2-Dichloroethene | 7.9 | 41 | 2.9 | 2.7 | 70 |
| Trans 1,2-Dichloroethene | nd | nd | nd | nd | 100 |
| Tetrachloroethene | nd | 60 | nd | nd | 5† |
| Trichloroethane | nd | 0.6 | nd | nd | 200 |
| Trichloroethene | 2.2 | 400 | 2.4 | 1.1 | 5† |
| Trihalomethanes | nd | nd | nd | nd | 80 |
| Vinyl Chloride | 2.7 | 2.9 | nd | 4.6 | 2 |

nd = not detected above detection limits
† = temporary modification in effect through 2009

Analytical results for the downgradient wells are shown in Table 11. Well 95299 remained dry throughout the year, as it has in past years. Wells 23296, 95099 and 95199 contained sufficient water for the scheduled semiannual sampling. However, when insufficient groundwater was present to collect the full suite of samples at one time, the VOC analyses were prioritized over the radiological sampling because of the smaller sample volume required.

VOC concentrations in both Wells 23296 and 95199 exceed RFCA Tier II Groundwater ALs, but are much lower than the concentrations seen in the influent. These two wells are located within the downgradient portion of the plume that is not collected by the system.

Well 95199 is downgradient of the collection system and upgradient of Pond B-2. Figure 8 shows the concentration of trichloroethene in Well 95199 over time. No other contaminants are

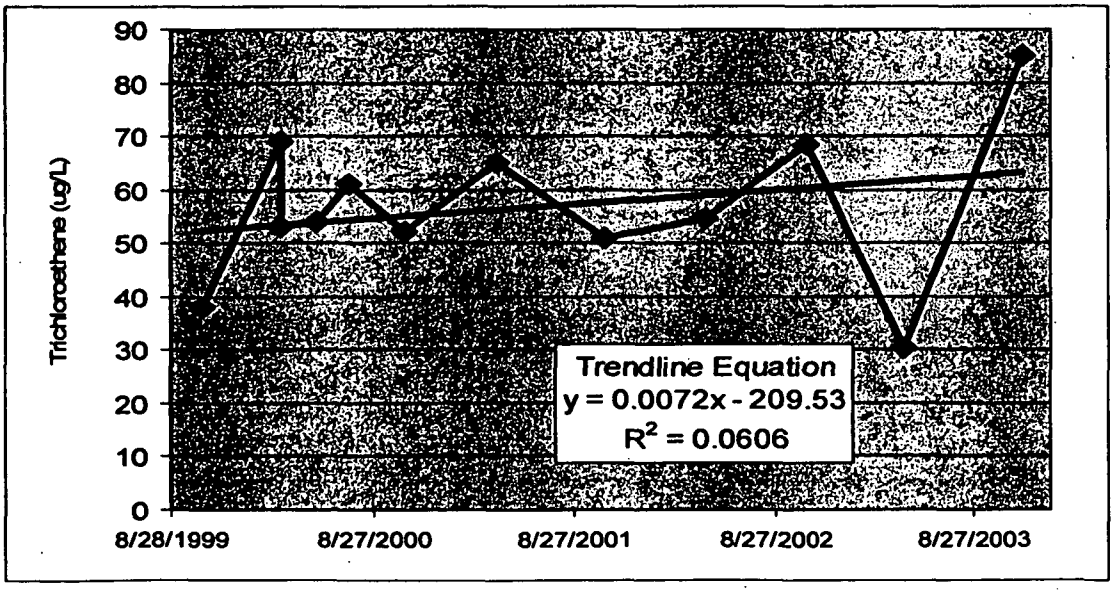
present at this well significantly over detection limits. Contaminant concentrations fluctuate, potentially due to groundwater flow from Pond B-2 at times and no consistent trend is apparent.

**Table 11. East Trenches Downgradient Well Analytical Results**

| Analyte | Well Location 23296 | | | | RFCA Tier II Groundwater AL | Unit |
|---|---|---|---|---|---|---|
| | 5/6/03 | 6/24/03 | 7/17/03 | 12/2/03 | | |
| Acetone | 10 | ND | ND | ND | 3,650 | ug/l |
| Carbon Tetrachloride | 2 | ND | 0.72 | 24.8 | 5 | ug/l |
| Chloroform | 2 | ND | 0.94 | 21.1 | 100 | ug/l |
| Tetrachloroethene | 4 | 14.1 | 5.92 | 19.6 | 5 | ug/l |
| Trichloroethene | 94 | 86.6D | 112 | 408D | 5 | ug/l |
| Uranium-233,234 | 15.5 | - | - | 15.4 | 1.06 | pCi/l |
| Uranium-235 | 1.39 | - | - | 0.571J | 1.01 | pCi/l |
| Uranium-238 | 11.9 | - | - | 11.8 | 0.768 | pCi/l |
| Total Uranium | ND | 34.5 | 36.2 | 37.9 | - | pCi/l |
| **Analyte** | **Well Location** | | | | **RFCA Tier II Groundwater AL** | **Unit** |
| | **95099** | | **95199** | | | |
| | **4/17/03** | **11/24/03** | **4/21/03** | **11/24/03** | | |
| 1,1-Dichloroethane | ND | ND | ND | 1.5 | 3650 | ug/l |
| 1,1-Dichloroethene | ND | ND | ND | 0.58 | 7 | ug/l |
| Tetrachloroethene | ND | 3 | 0.82J | 4.8 | 5 | ug/l |
| Trichloroethene | ND | 1.3 | 30.3 | 85.1 | 5 | ug/l |

- = Not sampled
D = diluted
J = detected at concentrations below the detection limit for this analysis
ND = not detected at the detection limit for this analysis
* = concentration exceeds RFCA Tier I Groundwater AL

**Figure 8. Trichloroethene Concentration in Well 95199**



Well 23296 is located near Pond B-3, where the East Trenches Plume discharges to surface water. Higher VOC concentrations observed at this well were an early indication that a remedial action should be considered for this plume. As can be seen in Table 11, VOC concentrations at Well 23296 exceed RFCA Tier II ALs. In the past, VOC concentrations also exceeded Tier I ALs at this well.

Groundwater trichloroethene concentrations at Well 23296 vary significantly (Figure 9). Figure 10 shows the sample results after the treatment system was installed. Contaminant concentrations in 2003 are lower than in the past. While there appears to be a downward trend, the data variation does not support a definite conclusion. Figures 11 and 12 show similar trends in tetrachloroethene concentrations. IMP monitoring is expected to continue at this location to determine if there is a downward trend in concentrations.

**Figure 9. Historical Trichloroethene Trend in Well 23296**

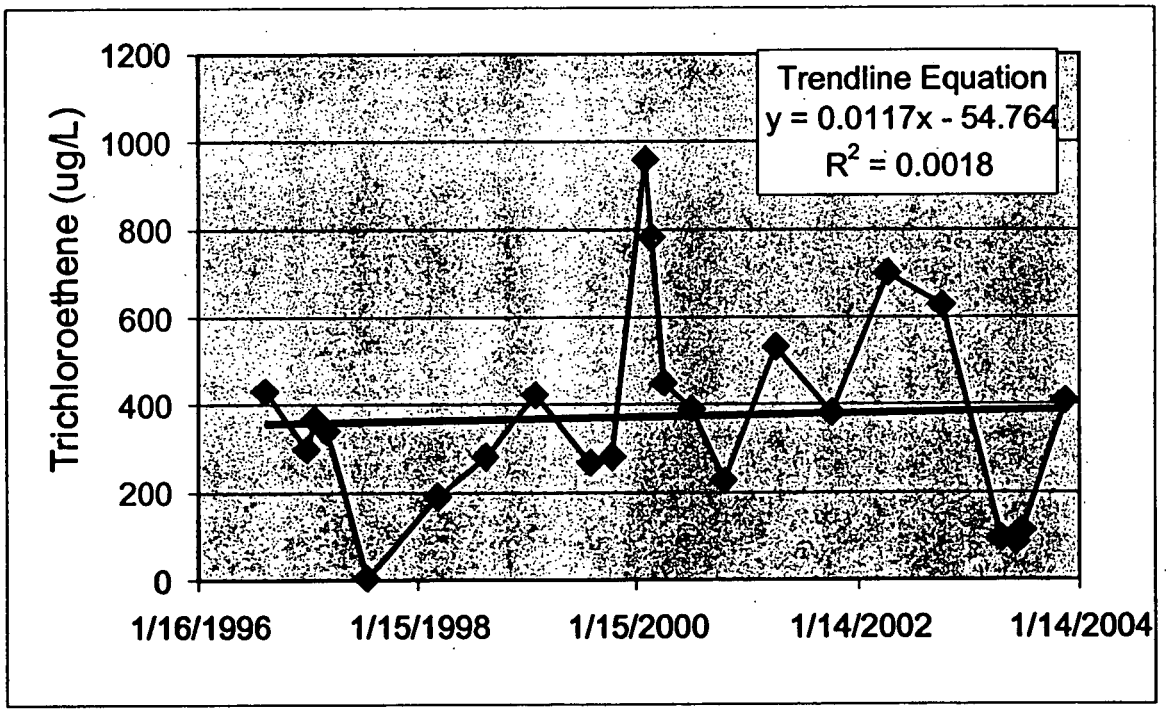


**Figure 10. Trichloroethene Levels in Well 23296 During System Operation**

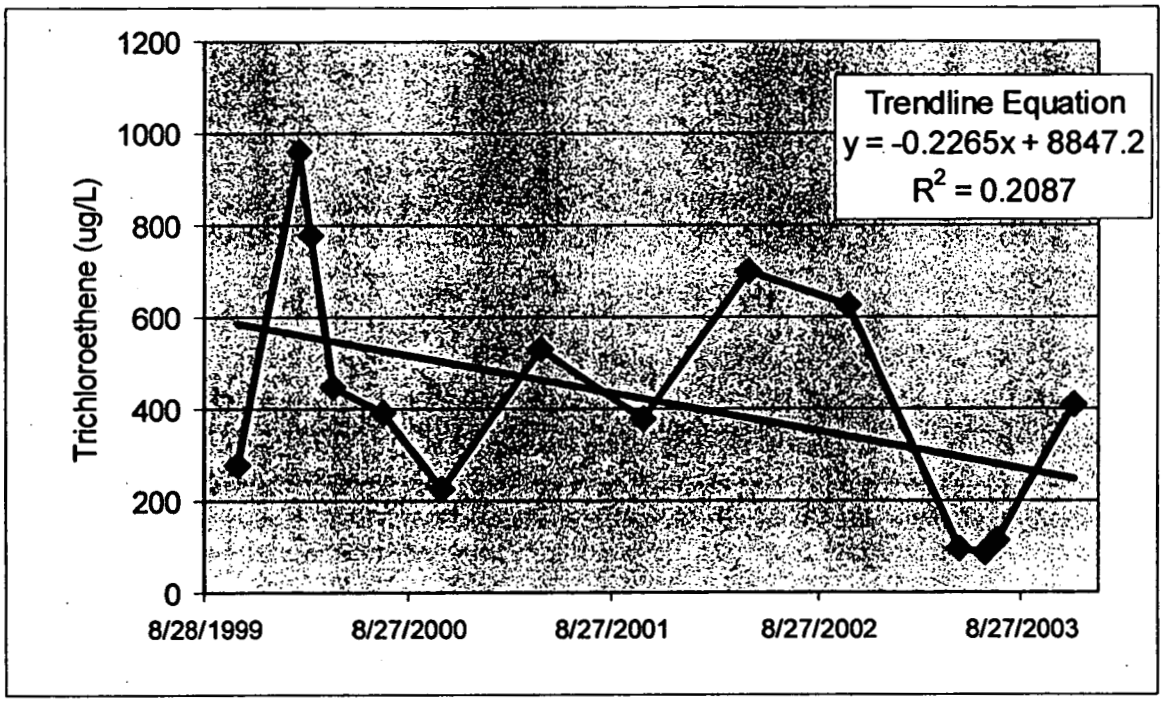



**Figure 11. Historical Tetrachloroethene Trend in Well 23296**

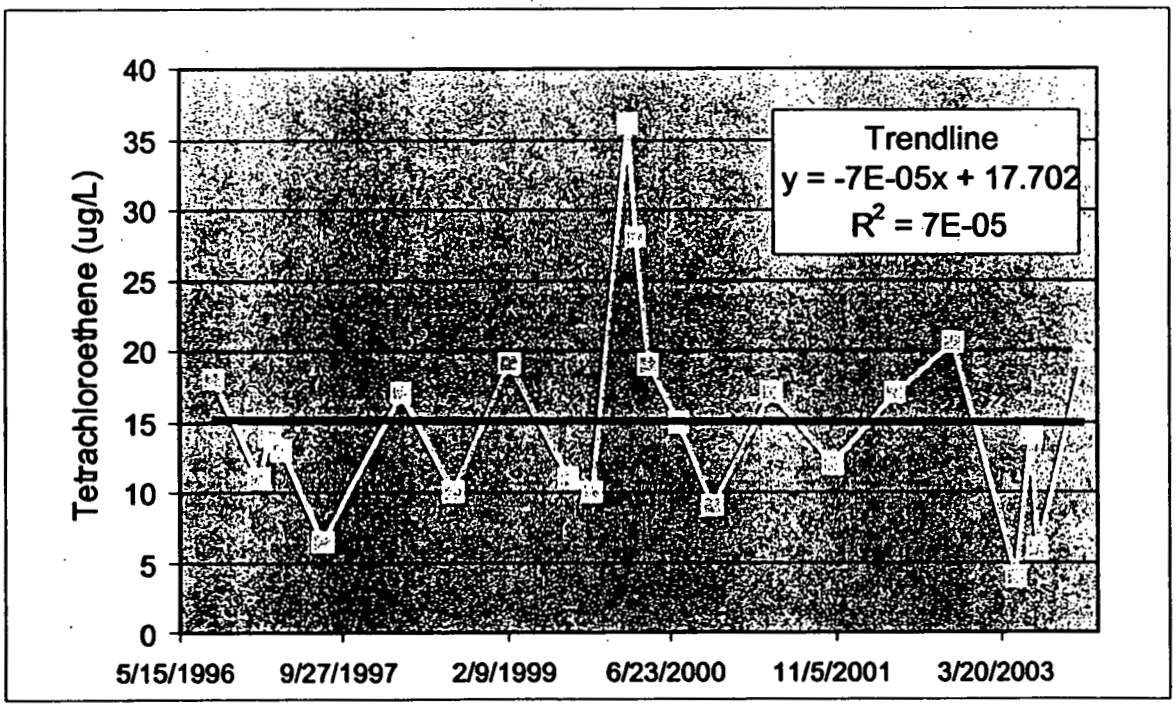
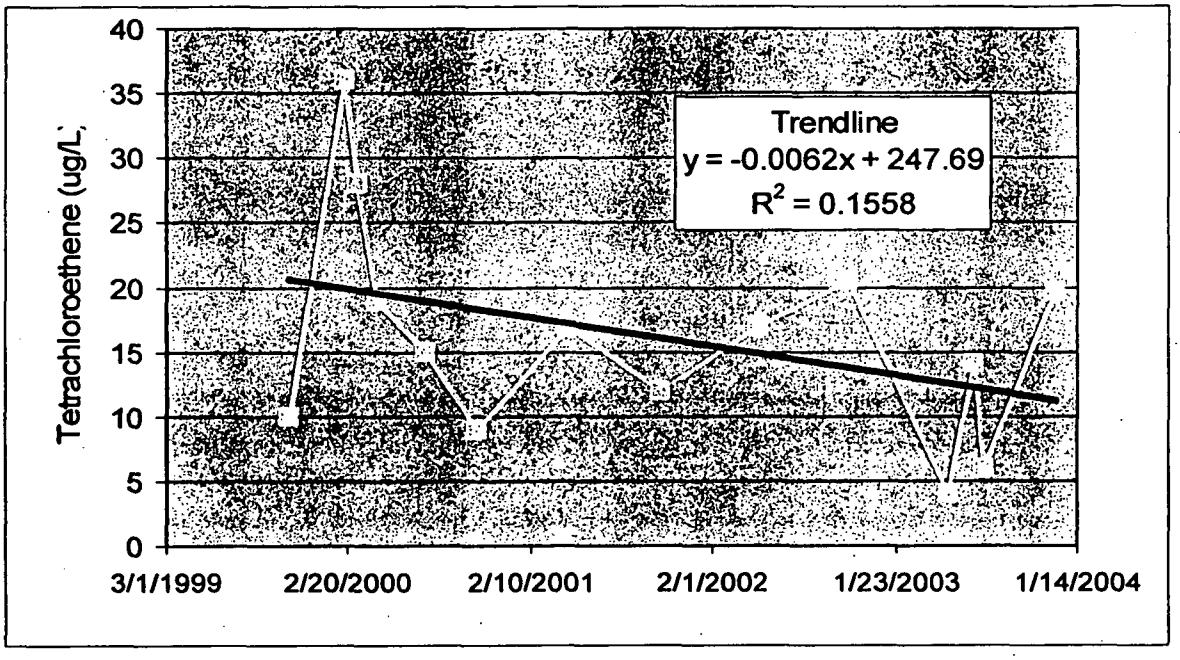


**Figure 12. Tetrachloroethene Levels in Well 23296 During System Operation**




Well 95099 is located east of the collection system, outside the plume boundary. It was installed to monitor whether the plume would expand to the east as a result of installation of the collection system. Up until November 2003, contaminants were not detected at this location. In November 2003, two of the three primary contaminants were detected in this well at low concentrations, below groundwater ALs. This location continues to be monitored to determine why this occurred.

### 3.2.2.3 Water Levels

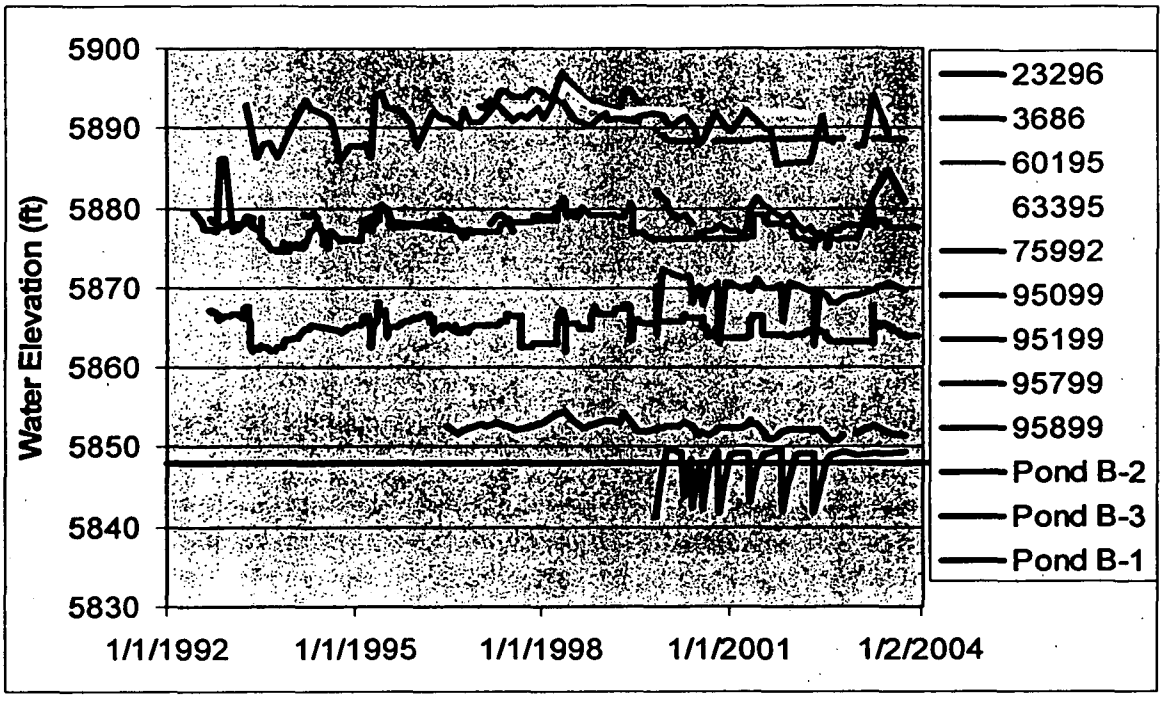
Water levels within and downgradient of the collection trench are now measured quarterly because of the consistent water level elevations. Monitoring results are presented in Table 12. Groundwater elevations in wells, piezometers and associated B-Ponds are shown on Figure 13.

**Table 12. East Trenches Plume Water Levels (Feet above MSL)**

| Well | Location | 01/06/03 | 04/07/03 | 07/02/03 | 10/03/03 |
|---|---|---|---|---|---|
| 23296 | Downgradient | 5851.76 | 5852.69 | 5851.61 | 5851.54 |
| 60195 | Downgradient | Dry | Dry | Dry | Dry |
| 63395 | Upgradient | Dry | 5891.61 | 5893.44 | NM |
| 75992 | Downgradient | 5887.87 | 5893.9 | 5889.37 | Dry |
| 95099 | Eastern | 5848.85 | 5849.21 | 5849.21 | 5849.41 |
| 95199 | Downgradient | 5869.04 | 5869.74 | 5870.69 | 5869.63 |
| 95299 | Downgradient | Dry | Dry | Dry | Dry |
| 95699 | Collection Trench | Dry | Dry | Dry | 5868.57 |
| 95799 | Collection Trench | 5876.26 | 5881.76 | 5884.82 | 5880.81 |
| 95899 | Collection Trench | Dry | 5888.75 | 5888.78 | 5888.74 |

NM = not measured

**Figure 13. East Trenches Plume System Water Elevations**




Three wells are immediately downgradient wells of the collection trench and one well is located to the east and downgradient of the collection trench (Figure 7). These wells continue to demonstrate that there is a strong gradient downward to the northeast. Well 95299 is always dry, providing evidence that there is no groundwater flow from the ponds or from groundwater bypassing the trench in this area.

Well 23296 is adjacent to Pond B-3 and shows less water level fluctuation probably because its water level is dominated by the water levels in Pond B-3. Pond B-3 pond water is held at a near constant elevation by its discharge pipe.

At Well 95199, located downgradient of the middle of the collection trench, groundwater elevations appear to be influenced by Ponds B-1 and B-2 and nearby South Walnut Creek. These ponds are isolated from the main drainage system and only collect local area drainage. Pond water is usually not discharged but is allowed to evaporate or infiltrate into the ground. Because of this, water levels rise in these ponds because of precipitation events. The fluctuations seen in the groundwater elevations for Well 95199 also appear to be the result of precipitation events and reflect influence of Pond B-2 on this area. The higher water levels in this well indicate that there may be some groundwater flow towards the collection trench from the north. As shown on Figure 13, the gradient appears to change direction over time, sometimes flowing from Pond B-2 to the well and towards the collection trench.

The groundwater elevation at Well 95099, located east of the collection trench, fluctuated the most, from 5,842 to 5,850 feet above mean sea level (msl). It is likely that this well is influenced strongly by precipitation events.

A recent concern was whether a high permeability zone encountered near Pond B-2 during trench installation might be a conduit for flow beneath the trench. When the collection trench was installed, there was flow into the excavation from both the upgradient and downgradient

side of the trench. This suggests that the hydraulic gradient on both sides of the collection trench is locally towards the trench. Groundwater flow from the downgradient side is likely a result of water stored in the B-Ponds. If the high permeability zone is acting as a conduit and was not cut off during collection trench installation, it could be bringing in pond water, not transporting contaminated groundwater downgradient. The elevation of the collection trench in this area is lower than the water level in the ponds during 2003, supporting this interpretation.

### 3.3 Operation and Maintenance

During 2003, system maintenance included raking the media in the treatment cells and system checks periodically over the course of the year. Site personnel performed quarterly water level monitoring and semiannual analytical sample collection. In addition, the discharge line to South Walnut Creek and the flow measurement flume were cleaned and recalibrated four times.

In January 2003, the discharge line from the flow meter became plugged. The line was partially cleared using a plumber's snake, but an obstruction in the line prevented the entire line from being cleared. The material removed from the discharge line appeared to be an iron bacteria. The bacteria form where the reduced, iron-rich effluent is re-oxygenated as it passes through the flow meter flume. Line cleaning continues periodically, and the entire line was subsequently cleared.

In September 2003, crust formation caused the treatment cells to plug. Replacement of the zero valent iron in both of the treatment cells was initiated. Both the iron and iron gravel/mixture were removed and replaced in both of the tanks. The lines were cleaned between the second vessel and the flow meter flume. The gravel layer was also replaced. After replacement was complete, normal operation of the system was resumed.

During the relatively brief periods when the treatment cells plugged and during media replacement, untreated water flowed into the Pond B-3 in the South Walnut Creek drainage. Based on the influent data, the predominant contaminant was trichloroethene. Samples were collected from Pond B-4, the Pond B-4 influent, Pond B-5 (3 samples) and surface water location SW64492 to determine the impacts from releasing this water. Only the sample from the Pond B-4 influent had a detectable quantity of trichloroethene at a concentration of 2.7 ug/l, below the surface water action level of 5 ug/l. In addition, acetone was detected at 4.1 ug/l in the Pond B-5 and cis-1,2 dichloroethene was detected in the Pond B-4 influent at a concentration of 3.2 ug/l. Chloroform, methylene chloride, naphthalene, vinyl chloride, and tetrachloroethene were detected in one or more of the samples at concentrations less than 1 ug/l.

### 3.4 Conclusions

The East Trenches Plume Treatment System is operating properly and successfully. The effectiveness was evaluated by comparing the objectives stated in the Decision Document to the system performance. The objectives evaluated were:

1. Intercept and treat VOC-contaminated groundwater at the distal end of the East Trenches Plume. Evaluated as collection system effectiveness (Section 3.4.1).
2. Protect surface water and reduce the VOC-contaminant mass loading in surface water, to the extent practicable. Evaluated as treatment system effectiveness (Section 3.4.2).

In addition, operations and maintenance information based on approximately five years of operation, described in section 3.3 is provided to allow further evaluation of overall effectiveness of this type of system for specific applications at RFETS.

### 3.4.1 Collection System Effectiveness

The system is collecting VOC-contaminated groundwater as shown by the following:

- The influent to the treatment cells consistently contains elevated VOCs (Table 8).
- Approximately 2.1 million gallons of water were collected and treated in 2003, approximately 8 million gallons since system installation in 1999. Water discharged without treatment did not pass through the flume and was not measured or otherwise included in this total.

The volumetric flow rates might be somewhat inflated due to water backing up into the flow meter flume due to a clogged discharge line, especially in February 2003. These peak flow rates do not appear to be associated with precipitation events and are probably a result of water backing up in the flume. However, it is evident that the system is collecting significant quantities of groundwater.

The collection trench intercepts contaminated groundwater in the alluvium and colluvium before it reaches surface water receptors. The East Trenches collection trench was not designed to intercept deeper bedrock flow. The collection trench is cut into the bedrock and likely does collect limited flow from the upper surface of bedrock. The subcropping Number One Sandstone was intercepted by the collection trench and the system collects groundwater transmitted by this unit. It also is collecting water from a highly permeable zone encountered at the west end.

Based on the estimates of groundwater flow in the East Trenches Plume PAM, the projected recovery from the trench was 5.3 gallons per minute. As shown on Figure 2, the captured flow often exceeds this flow rate. Even during 2003 when there were still impacts from the drought, the average flow rate for the year was 4.23 gallons per minute. Based on this, the collection system is operating as designed, and bypass is limited in extent.

Based on the downgradient wells, it appears that there is a direct connection between contaminated groundwater downgradient of the collection trench and surface water. However, groundwater elevations in this area are dominated by the stream channel flow and the B-Ponds as opposed to water flow under or around the collection trench.

Water level data from wells and piezometers, together with the volume of water recovered in the collection system, indicate that the collection trench is collecting groundwater, thought to be primarily from the upper hydrostratigraphic unit (UHSU). Based on the groundwater elevations in the trench piezometers, some groundwater pooling is occurring at the west end of the collection trench. Even with the pooling, water elevations within the collection trench are lower than water elevations in the surrounding area prior to system installation.

The downgradient plume might be a result of the residual groundwater plume cutoff by the collection trench and/or a result of residual soil contamination left by the plume from earlier periods of higher concentrations.

The hydraulic gradients and saturated thickness in this area of Well 23296 could cause flushing of the contaminants. Although there appears to be decreasing trend in this well since the trench was installed, there are not sufficient data to verify this trend at this time. After evaluation of

alternatives, an accelerated action is being proposed in the Draft Groundwater IM/IRA (DOE, 2004c) to address the contamination in this area of the plume.

If there is a deeper path of migration under the trench, it is likely through the deeper bedrock that the trench was not intended to intercept. However, contamination trends appear to be decreasing slightly in Well 23296 and the concentration in Well 95199 fluctuates erratically with no discernable overall trend. Prior to installation of collection system, there did not appear to be any concentration trend in Well 23296. After it was installed, there was an apparent decreasing trend. If significant underflow were occurring, downgradient well concentrations would likely not be decreasing.

### 3.4.2 Treatment System Effectiveness

As previously noted, plugging of the zero-valent iron reduced the effectiveness of the system to the point where RFCA Surface Water ALs were not met in April and September. Samples taken in November 2003 demonstrate that the normal removal efficiency of the system was restored once the zero-valent iron was replaced. Only trichloroethene at 5.7 ug/l and methylene chloride at 17 ug/l were above the RFCA Tier II Groundwater ALs of 5 ug/l each. Based on the bench scale tests, the system was not expected to be effective at removing methylene chloride, which could be present as a treatment degradation product. As shown, the system is effective in removing the major contaminants present in groundwater for this plume.

The treatment system is operating as designed and about 21,000 grams of VOCs are removed each year. The change-out of the iron in the system was anticipated although it occurred a little earlier than predicted, at 4 years rather than 5 years. Since the zero valent iron has been replaced, the East Trenches Plume Treatment System is again fully operational and treating contaminated groundwater to specified system performance requirements.

## 3.5 Planned Activities

Additional steps are being taken to reduce plugging and provide better monitoring of the treatment cells. These steps include the following:

- Installation of downspouts on the influent opening in each treatment cell to reduce the introduction of dissolved oxygen into the water
- The partial sealing of treatment cell doors to reduce introduction of dissolved oxygen into water at the top of the tank
- Geochemical modeling of the water in the tank to evaluate precipitation and oxidation processes
- Periodic removal of the upper gravel layer to reduce precipitates and plugging of the treatment cells
- Preparation of more detailed guidance for operating and maintaining the treatment system
- Monitoring of water levels in the vessels themselves

In addition, the gravel layer will be replaced because it appears that it has been exposed to air and become oxidized.

Ongoing maintenance (i.e., raking the iron filings and monitoring) will continue. In addition, periodic cleaning of the discharge line from the flow meter is necessary due to the buildup of iron bacteria. Sampling of the treatment system is expected to continue semiannually. Analytical

results will be monitored to indicate when the iron needs to be replaced. The Operations and Maintenance Manual will be updated to reflect current conditions.

## 4.0 SOLAR PONDS PLUME TREATMENT SYSTEM

The Solar Ponds Plume Treatment System was installed in 1999 pursuant to the *Final Solar Ponds Plume Decision Document, Major Modifications to the Final Proposed Interim Measures/Interim Remedial Action Decision Document for the Solar Evaporation Ponds Operable Unit 4, 1992* (Solar Ponds Plume Decision Document) (DOE, 1999c). System installation is documented in the *Draft Solar Ponds Plume Completion Report* (DOE, 2000b – not finalized). The Solar Ponds Plume Treatment System collects and treats low-level nitrate and uranium contaminated groundwater from the Solar Ponds groundwater plume. Installation of the 1,100 foot long collection system and treatment cell containing wood chips and reactive iron was completed in 1999 (Figure 14). Treated water is discharged back into the groundwater on the downgradient side of the treatment cells through a discharge gallery that was designed to overflow to the surface when the surrounding soils are saturated. This overflow discharges to the surface immediately downgradient of the treatment cell near North Walnut Creek.

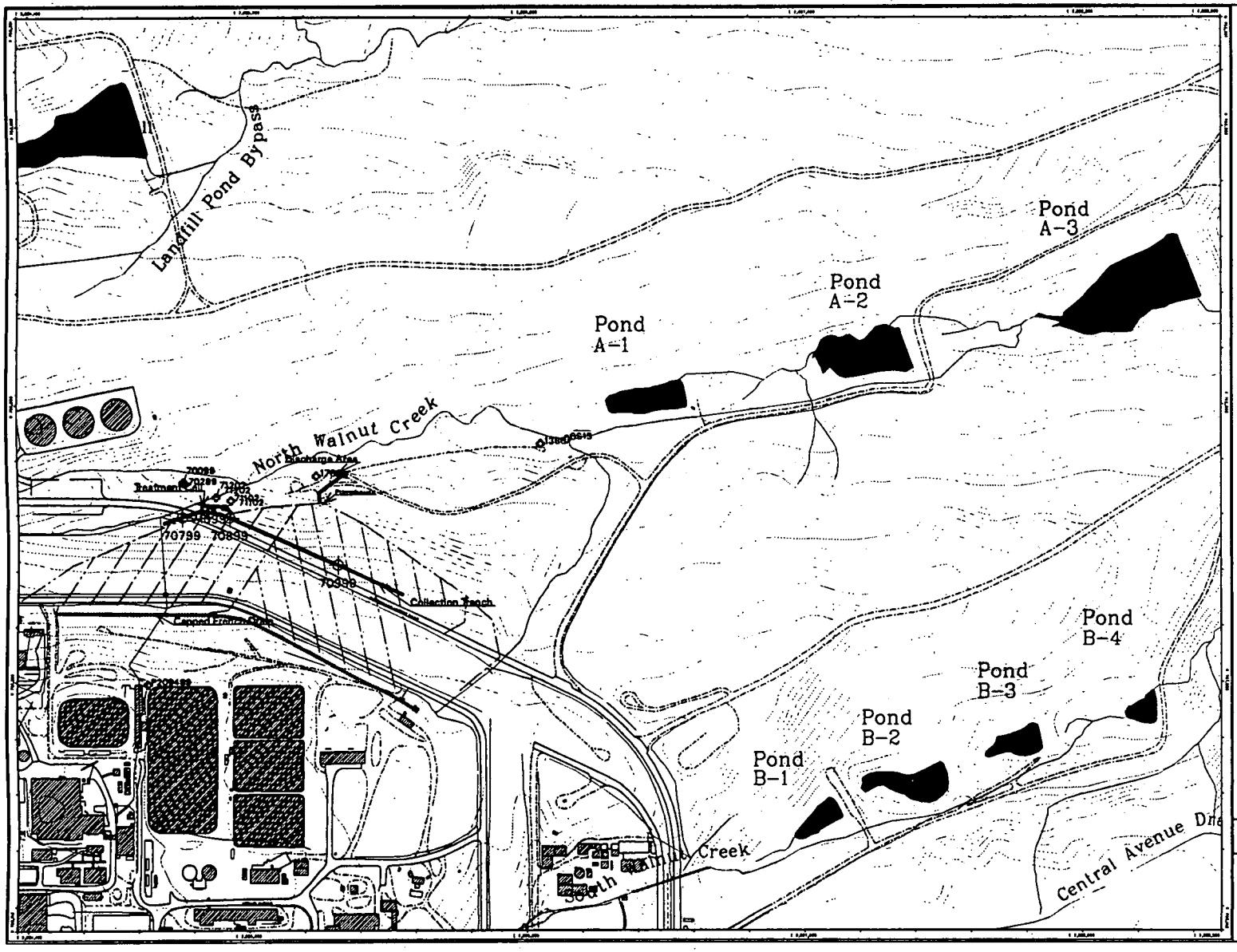
The Preble's Meadow Jumping Mouse (a federally listed threatened species under the Endangered Species Act) is present at the optimal location for a flow-through treatment cell. The treatment cell was located immediately adjacent to the collection trench and not 400 feet downgradient as was originally planned. As a result, the collection trench for this system was required to hold approximately 11 feet of groundwater within a several-hundred-foot section of the collection trench to develop sufficient hydraulic head for the groundwater to flow into the treatment cell.

In October 2002, a solar-powered pump was installed within the collection trench to pump the collection trench water into the treatment cell and to maintain a lower level of groundwater within the collection trench. This allows the collection trench to operate more as it was originally designed and eliminates the need for water to be stored within the collection trench. By maintaining a lower water level in the trench, more water will be collected and it should reduce or prevent water from bypassing the treatment system. Installation of the solar-powered pump increases the amount of groundwater treated by the system.

### 4.1 Decision Document Objectives

Pursuant to the Solar Ponds Plume Decision Document (DOE, 1999c), the objectives for this project were to:

1. Protect North Walnut Creek by reducing the mass loading of nitrate to surface water and ensure that surface water standards are met in the Creek.
2. Design and install a passive system to intercept and treat the contaminated groundwater of the SPP to remove nitrate.




## Figure 14
### Solar Ponds Plume Treatment System Locations

**EXPLANATION**

- Interceptor Trench System
- In Trench Piezometer Location
- Monitoring Well

**Standard Map Features**

- Buildings and other structures
- Demolished buildings and Other Structures
- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (5-Foot)
- Paved roads
- Dirt roads

*DATA SOURCE BASE FEATURES:*

*Buildings, fences, hydrography, roads and other structures from 1994 aerial Prysmar data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs, 1996.*

*Topographic contours were derived from digital elevation model (DEM) data by Mountain Knudsen [MK] using ESRI Arc TIN and LATTICE to process the DEM data to ensure 5-foot contours. The DEM data was collected by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Prysmar at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.*

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Scale = 1 : 4140
1 inch represents 345 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: CH2MHILL

Prepared for: KAISER-HILL

February 05, 2003

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3. Design and construct the reactive barrier system in a manner which minimizes the generation of low-level mixed waste and/or hazardous waste and protects the habitat of the Preble's Meadow Jumping Mouse, which was added to the Threatened Species List on May 18, 1998.
4. Design the reactive barrier system to allow easy access for operations and maintenance and reactive media replacement or removal.
5. Evaluate effectiveness of reactive barrier system in removing nitrate.
6. Evaluate long-term effectiveness of the treatment system once it has been in operation for several years.

This report describes how objectives 1, 5 and 6 are met. Objectives 2 through 4 were previously met during design and construction and are not discussed in this report. Section 5.5 of the Solar Ponds Plume Decision Document contains Preliminary Decision Rules that are used in the effectiveness evaluation for Objectives 5 and 6 in this Report. These rules are:

Preliminary decision rules for the project, as stated in the decision document, are as follows (DOE, 1999c):

1. Steadily increasing water levels *(in the collection trench piezometers)* may be an indication that the media is plugged, requiring replacement.
2. If effluent concentrations exceed system performance objectives, then monthly or more frequent sampling will be performed until the cause is determined. If a corrective action is required, then monthly effluent sampling will continue for at least three months after a corrective action is implemented to ensure that the action is sufficient.
3. Based on preliminary calculations provided by CDPHE, the current stream standard will be achieved if effluent concentrations are 500 mg/l. Effluent concentrations are expected to achieve this level. These preliminary calculations indicate that effluent concentrations must meet 50 mg/l to achieve surface water standards after 2009. Decision rules will be refined as performance monitoring trends are established and in anticipation of the decrease in the stream standard from 100 mg/l to 10 mg/l after 2009.
4. Groundwater monitoring will continue during and after the remedial action has been completed, as described in the IMP. Groundwater wells 1786 and 1386 currently monitor the drainage and will be, at a minimum, monitored for nitrate and uranium. An additional well cluster to the north of the barrier will be installed to provide additional data and for performance monitoring purposes. The frequency of sampling and analytical suites will be consistent with the IMP and will measure uranium and nitrate concentrations.
5. Performance monitoring in the North Walnut Creek Drainage will be implemented at station GS13 to monitor changes in surface water quality as a result of the selected remedy. This location was selected because it is immediately downstream of where the groundwater plume intersects the drainage. The loading to the stream will be evaluated to determine long-term system performance and will be reported on an annual basis. In accordance with the Action Level Framework, if the stream concentrations exceed stream standards, then an evaluation will be performed after consultation with the regulators.
6. If stream standards are being met consistently at GS13 and if simple modeling techniques show that the stream standards would be met without treatment, based on the influent plume concentrations and flow rate, and the stream concentrations and flow rate that exist at that time, then treatment will be discontinued. This system is expected to continue operations until after Site closure when stream flow and concentrations have stabilized. The

system will be abandoned in place as a flow-through system. System shutdown will be re-evaluated as part of the final Site Corrective Action Decision/Record of Decision (CAD/ROD).

## 4.2 Treatment Performance, Monitoring and Maintenance

The monitoring locations and frequency to assess system performance required by the Solar Ponds Plume Decision Document are shown in Table 13. While not required by the Solar Ponds Decision Document, sampling of the discharge gallery began in February 2000 to monitor the concentrations at this downgradient location. Water is often flowing at this location even when it is not at the treatment cell effluent.

The Preliminary Decision Rule 3 requires the effluent to have nitrate concentrations below 500 mg/l to protect surface water at the surface water standard of 100 mg/l. While the treatment objectives focused on removing nitrate contamination, the treatment system is also designed to remove uranium contamination. The surface water standard for total uranium is 10 pCi/l.

**Table 13. Monitoring Requirements for the Solar Ponds Plume System**

| Task | Month 1-6 | Months 7-12 | Subsequent Years |
|---|---|---|---|
| Treatment System Influent – piezometer adjacent to treatment cell | Monthly | Quarterly | Semi-Annually |
| Treatment System Effluent – metering manhole | Monthly | Quarterly | Semi-Annually |
| Downgradient Surface Water Quality – GS13 | Monthly | Quarterly | Semi-Annually |
| Hydraulic Head in Collection Trench – water level measurement | Monthly | Quarterly | Semi-Annually |

### 4.2.1 Treatment Performance

For the period January 1, 2003 through December 29, 2003, 339,000 gallons of water were treated as compared to 5,600 gallons in 2002. The sump was redeveloped in 2003 and this was a wetter year. Flow rates ranged from 0 to 6.72 gpm. The total volume of water treated by the Solar Ponds Plume Treatment System between March 2000 and December 29, 2003 was 797,000 gallons. Table 14 provides the monthly influent and effluent data for 2003.

The treatment system is effectively removing nitrate to well below the performance requirement and is removing total uranium to below the surface water standard. The higher concentrations of nitrate and uranium at the discharge gallery apparently are caused by contaminated groundwater at higher concentrations than the treated effluent. Because the water is discharged through perforated piping, there is no way to determine the flow rate at this location.

Figures 15 and 16 show nitrate concentrations and uranium activities since the system was installed. Influent and discharge gallery nitrate concentrations appear to be increasing. Uranium in the discharge gallery also appears to be increasing.

## Table 14. Solar Ponds Plume Treatment System 2003 Analytical Results

| Collection Date | SPP Influent | | SPP Effluent | | SPP Discharge Gallery | |
|---|---|---|---|---|---|---|
| | Nitrate mg/l | Total Uranium pCi/l | Nitrate mg/l | Total Uranium pCi/l | Nitrate Mg/l | Total Uranium pCi/l |
| 30-Jan-03 | 190 | 24.55 | No flow | No flow | 230 | 42.25 |
| 26-Feb-03 | 200 | 24.16 | No flow | No flow | 150 | 36.45 |
| 25-Mar-03 | 170 | 20.61 | 18 | 0.014 | 78 | 13.77 |
| 16-Apr-03 | 150 | 27.11 | 31 | 0.081 | 230 | 39.06 |
| 12-May-03 | 140 | 24.36 | 0.27 | 0.098 | 250 | 36.60 |
| 13-Jun-03 | 110 | 22.37 | 0 | 0.26 | 290 | 43.25 |
| 30-Jul-03 | 160 | 23.03 | 0.11 | 0.105 | 300 | 51.10 |
| 27-Aug-03 | 180 | 21.75 | 0.094 | 0.0209 | 140 | 41.93 |
| 29-Sep-03 | 170 | 24.25 | No flow | No flow | 290 | 44.21 |
| 29-Oct-03 | 200 | 26.45 | No flow | No flow | 320 | 47.62 |
| 24-Nov-03 | 180 | 26.88 | 0.46 | 0.0512 | 300 | 37.56 |
| 31-Dec-03 | 290 | 24.87 | No flow | No flow | 370 | 42.25 |

SPP = Solar Ponds Plume
mg/l = milligrams per liter
pCi/l = picoCuries per liter

## Figure 15. Solar Ponds Plume Treatment System Nitrate Concentrations

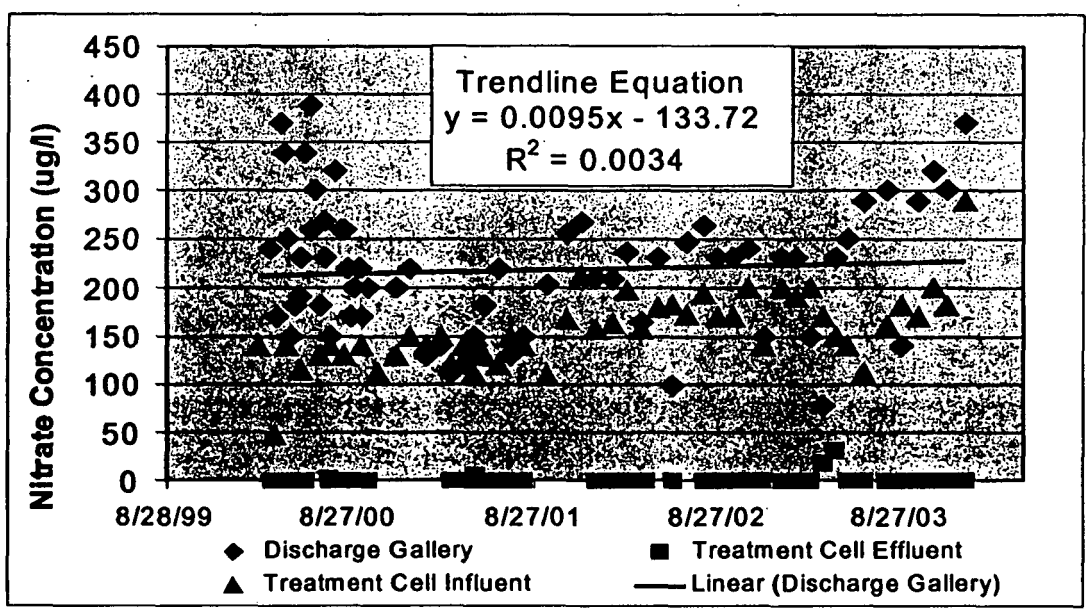
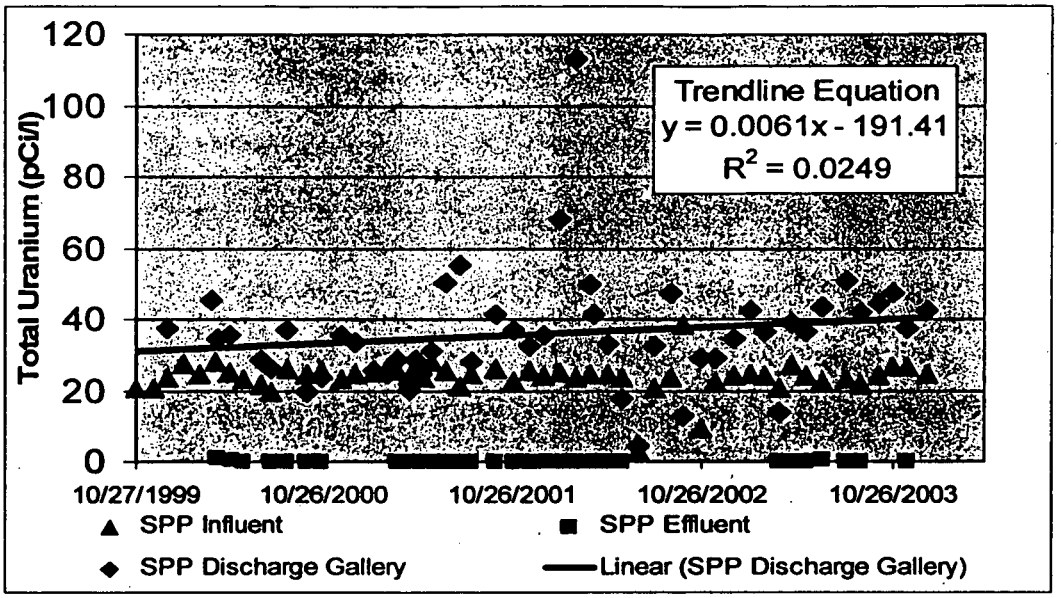


**Figure 16. Solar Ponds Plume Treatment System Uranium Activities**




The approximate contaminant mass removed is shown in Table 15 and was calculated based on the total measured flow and the midpoint of the contaminant concentration range from Table 14. Previous years are included for comparison.

**Table 15. Approximate Contaminant Mass Removed at Solar Pond Plume Treatment System**

| Contaminant | Influent (ug/l) | Effluent (ug/l) | Removed conc.(ug/l) | Volume Treated (l) | Total Mass Removed (g or uCi)) |
|---|---|---|---|---|---|
| **Calendar Year 2003** | | | | | |
| Nitrate | 200,000 | 15,500 | 88,100 | 1,283,300 | 113,059 |
| Total Uranium* pCi/l | 23.86 | 0.060 | 23.8 | 1,283,300 | 30.55 |
| **Calendar Year 2002** | | | | | |
| Nitrate | 170,000 | 245.00 | 169,755 | 21,200 | 3,599 |
| Total Uranium* pCi/l | 20.79 | 0.12 | 20.67 | 21,200 | 0.4 |
| **Calendar Year 2001** | | | | | |
| Nitrate | 159,500 | 2,650 | 156,850 | 1,604,400 | 251,650 |
| Total Uranium* pCi/l | 24.64 | 0.08 | 24.6 | 1,604,400 | 39.4 |
| **Calendar Year 1999/2000** | | | | | |
| Nitrate | 150,000 | 550 | 149,450 | 109,600 | 16,380 |
| Total Uranium* pCi/l | 23.95 | 0.51 | 23.4 | 109,600 | 2.6 |

In the past, higher flow rates have not appeared to have an effect on removal efficiency for nitrates. However with the very high flow rates seen after the March snowstorm, there did appear to be a significant increase in nitrates in the effluent even though there was not an increase in the influent. The reason for this increase is not known, however, monitoring of the effluent will continue to determine if this was due to conditions at the time, or if there is an

increasing trend that may indicate that the media in the cells have lost some of their treatment capacity (break through).

A contributing factor might have been that the cells were probably partially dewatered prior to the snowstorm because of minimal flow rates due to a plugged screen in the recovery trench sump. Although the sump was redeveloped a few weeks before the snowstorm, there may not have been enough time for the microbial community in the cells to reestablish itself, resulting in increased nitrate concentrations in the effluent.

### 4.2.2 Groundwater Monitoring

Pursuant to the Solar Ponds Plume Decision Document, groundwater monitoring is conducted as described in the IMP. Wells 1786 and 1386 currently monitor uranium and nitrate concentrations in the downgradient groundwater.

#### 4.2.2.1 Upgradient Water Quality

Well P209489 was previously used to monitor the upgradient water quality. This well was removed as part of the Solar Ponds remedial action and replaced with well 79202. Well 79202 had 320-480 milligrams per liter (mg/l) of nitrate/nitrite and uranium-233/234, 235 and 238 were 40.3 - 52.3 picoCuries per liter (pCi/l), 2.19 - 6.35 pCi/l and 35.3 - 46.5 pCi/l, respectively. The concentration and activity levels are similar to past levels in well P209489, about two times the levels in the influent. Well 79302 was also recently installed east of well 79202. Well 79302 had 3,000-3,200 mg/l of nitrate/nitrite and uranium-233/234, 235 and 238 were 61.8 - 80.2 pCi/l, 2.25 - 2.53 pCi/l, and 40.4 - 48.4 pCi/l, respectively. Although the uranium activities are similar to those in well 79202, the nitrate/nitrite concentrations are almost an order of magnitude higher.

Nitrate concentrations as high as those in Well 79302 have not been observed in the influent. It is likely that, due to dilution and dispersion, these concentrations will not be seen in the influent. However, based on these results, the influent concentration of nitrate to the treatment system may increase. Because the treatment system's removal efficiency does not appear to be impacted by higher nitrate concentrations as it is by higher flow rates, higher concentrations are likely to be removed to meet the Preliminary Decision Rule 3, 500 and 50 mg/l nitrate values. Based on performance to date, the treatment system will effectively treat these higher concentrations except potentially during periods of higher than average flow.

#### 4.2.2.2 Downgradient Water Quality

Groundwater samples were collected and analyzed quarterly from the three downgradient wells and data are provided in Table 16. The new piezometers (71102 and 71202) measure water levels and are not sampled. Wells 70099 and 70299 are twinned wells in the colluvium and the bedrock, respectively. Nitrate concentrations immediately downgradient in Wells 70099 and 70299 are significantly lower than those observed in both the collection trench and the discharge gallery. As previously observed, the uranium activity in the colluvial well (Well 70099) exceeds background activities and is higher than elsewhere in the collection and treatment system. In addition, the uranium activity is much higher than that of the adjacent bedrock well, possibly indicating a pre-existing higher activity in the colluvium. Groundwater from well 70099 was analyzed using ICP/MS for uranium isotopes, and the signature is consistent with naturally occurring uranium.

## Table 16. Solar Ponds Plume Downgradient Well Analytical Results

| Well | Date | Nitrate/Nitrite (mg/l) | Uranium-233,-234 (pCi/l) | Uranium-235 (pCi/l) | Uranium-238 (pCi/l) |
|---|---|---|---|---|---|
| 1786 | 1/9/03 | | 36 | 1.64 | 25.1 |
| | 1/30/03 | 326 | 32.9 | 2.78 | 25.7 |
| | 2/25/03 | 341 | 34.2 | 1.77 | 24.4 |
| | 3/26/03 | 270 | 33 | 2.75 | 25.4 |
| | 4/22/03 | 310 | 18.3 | 0.908 | 11.8 |
| | 5/22/03* | - | 29.2 | 2.96 | 22.7 |
| | 6/22/03* | - | 3.5 | 0.137 | 2.52 |
| | 8/21/03 | 426 | 32.6 | 2.04 | 22.6 |
| | 10/14/03 | 380 | 31 | 1.21 | 23.1 |
| 70099 | 1/16/03 | 1.1 | 106 | 3.58 | 75.1 |
| | 5/12/03 | 1.2 | 102 | 6.64 | 78.2 |
| | 8/12/03 | 1.2 | 103 | 3.4 | 74.2 |
| | 10/15/03* | 1.3 | 78.8 | 3.28 | 58.7 |
| 70299 | 1/16/03 | 0.044B | 5.09 | 0.214 | 3.45 |
| | 4/23/03 | 0.072 | 5.64 | 0.369 | 4.2 |
| | 9/8/03 | ND | 6.09 | 0.319 | 4.27 |
| | 10/15/03* | 0.036B | 4.82 | 0.261 | 2.77 |

* = Uranium samples were filtered.
- = Not sampled
B= Detected in blank

Well 1786 is located farther downgradient of the collection trench, just upgradient of the discharge gallery. Nitrate concentrations at this location are currently 270 to 426 mg/l, much higher than what is observed in the treatment system influent or at the discharge gallery. Uranium activities in this area are also consistently elevated. The source for this downgradient plume is believed to be from a past leak of higher uranium- and nitrate-contaminated groundwater from the pre-existing Interceptor Trench System (ITS) sump. Observations of this sump have shown that it was not watertight and historical data from this location have high nitrate levels in the water and sediment. The sediment sample collected from the sump in March 2003 had a nitrate concentration of 159 milligrams per kilogram (mg/kg), showing that the sump is no longer a significant source of contamination. (Note: for comparison, the Wildlife Refuge Worker soil action level for nitrate is 1,000,000 mg/kg).

Flow from the area around Well 1786 to the discharge gallery is a likely explanation for higher activities in the discharge gallery than the treatment system effluent concentration. Although cleaner water is coming from the treatment system effluent, the flow rates have been low. Concentrations in the discharge gallery probably reflect upgradient residual contamination in the immediate area more than the treatment system discharge. These may take a long time to equilibrate with the waters from the discharge gallery. However, nitrate concentrations in Well 1786 are not a lot higher than the discharge gallery, so it does not appear at this time that discharge gallery concentrations will increase much more especially if flow through the treatment system is improved.

Well 1386 continues to be monitored; however, it is farther downgradient and does not appear to have been influenced by the Solar Ponds plume. Nitrate/nitrite data from 1995 to 2004 is below 0.4 mg/l, except for one 3.5 mg/l value. This is significantly higher than the other data and it appears to be an outlier. During the same period, the total uranium ranged between 10.45 and 24.39 pCi/l and averaged about 16 pCi/l for filtered and unfiltered samples combined. This was higher than an upgradient well, however, ICP/MS analyses show that the uranium is natural, and not part of the Solar Ponds plume. Since startup of the treatment system in 1999, nitrate/nitrite concentrations remain below 0.33 mg/l and averaged 0.09 mg/l. Total uranium isotopes since startup are between 10.5 and 24.5 pCi/l. Because nitrate is more mobile than uranium, the low nitrate concentrations here indicate that the Solar Pond plume has not impacted this area.

Water quality was measured at the Solar Ponds Plume discharge gallery; surface water station GS13, located in North Walnut Creek immediately downgradient of the Solar Ponds Plume; and downgradient Pond A-3, which accepts the water that passes through GS13. GS13 and Pond A-3 were monitored frequently to verify that concentrations at both locations are below the temporary modification stream standard for nitrate of 100 mg/l. Table 17 provides a summary of these analytical data.

As stated in Decision Rule 3, the current stream standards are being met with the concentrations seen at the discharge gallery. As stated in Decision Rule 5, loading to the stream is evaluated in this document. Based on the average removal efficiency in 2003, the influent concentration of nitrate was reduced by an average of 95% below that expected if no treatment system was in place. This represents a significant decrease in loading to the stream. A healthy vegetation population has established around the discharge gallery, indicating that additional mass removal in the discharge gallery area is taking place through phytoremediation.

GS13, located in North Walnut Creek, is the performance monitoring location for the Solar Ponds Plume Treatment System. In 2003, the nitrate concentrations were generally higher than in 2002. The State of Colorado compares the 85th percentile of water quality data for a given stream segment against the applicable stream standard. As previously mentioned, preliminary Decision Rule 3 requires the effluent to have nitrate concentrations below 500 mg/l to protect surface water at the surface water standard of 100 mg/l.

For 2002, the 85th percentile concentration of nitrate was 32.3 mg/l as compared to 46.9 for 2003, which equates to a 45% increase. In 2002, the nitrate concentration also increased and was attributed to decreased flows in North Walnut Creek as a result of persistent drought conditions. In 2003, there were continuing drought effects; however, it appears that the 2003 increase is primarily due to movement of the nitrate plume on the downgradient side of the groundwater collection trench.

The nitrate concentrations still remain well below the applicable surface water standard of 100 mg/l (DOE, 1999c). At Pond A-3, located downstream of GS13, nitrate concentrations remained about the same as they were in 2002. The average nitrate concentration at A-3 was 3.7 mg/l and none of the values exceeded 10 mg/l in either 2002 or 2003. The concentrations are significantly lower in Pond A-3 than in GS13, probably due in part to dilution from downstream water sources and nitrate removal by algae and other plants in and near the Pond, resulting in some phytoremediation. Figure 17 shows the nitrate concentrations in the discharge gallery, Pond A-3 and the surface water location GS13.

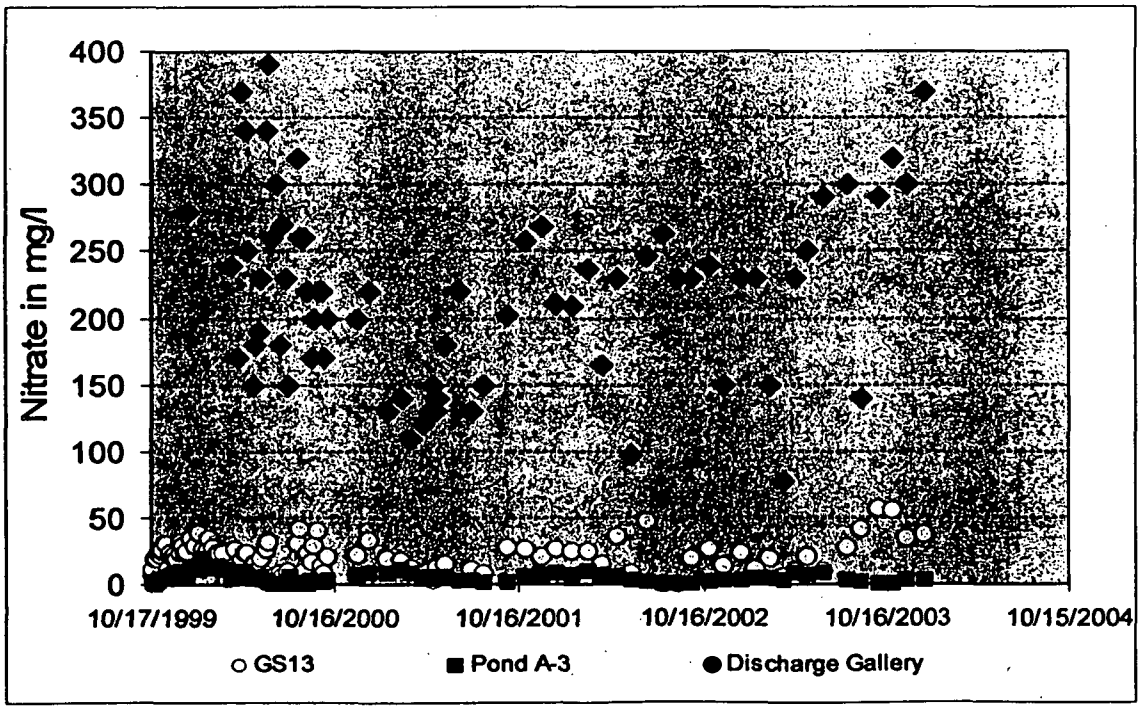
## Table 17. Solar Ponds Plume Summary of Downgradient Surface Water Locations

| Date | SPP Discharge Gallery | GS13 | Pond A-3 | SPP Discharge Gallery | GS13 |
|---|---|---|---|---|---|
| | Nitrate (mg/l) | | | Total Uranium (pCi/l) * | |
| 30-Jan-03 | 230 | 11 | 4.4 | 42.25 | 7.94 |
| 26-Feb-03 | 150 | 20 | 4.2 | 36.45 | 10.72 |
| 25-Mar-03 | 78 | 5.4 | 2.1 | 13.77 | 1.99 |
| 16-Apr-03 | 230 | 9.6 | 8.9 | 39.06 | 5.16 |
| 12-May-03 | 250 | 21 | 7.4 | 36.60 | 7.19 |
| 13-Jun-03 | 290 | 10 | 8 | 43.25 | 3.91 |
| 30-Jul-03 | 300 | 27 | 2.8 | 51.10 | 8.16 |
| 27-Aug-03 | 140 | 42 | 0.72 | 41.93 | 11.11 |
| 29-Sep-03 | 290 | 57 | 0.4 | 44.21 | 13.12 |
| 29-Oct-03 | 320 | 56 | 0.68 | 47.62 | 17.41 |
| 24-Nov-03 | 300 | 34 | 2.6 | 37.56 | 14.58 |
| 31-Dec-03 | 370 | 37 | 2.4 | 42.25 | 13.12 |
| **Minimum** | 78 | 5.4 | 0.4 | 13.77 | 1.99 |
| **Maximum** | 370 | 57 | 8.9 | 51.10 | 17.41 |
| **Average** | 245.7 | 27.5 | 3.7 | 39.67 | 9.53 |

* = Uranium is not measured at Pond A-3, SPP = Solar Ponds Plume

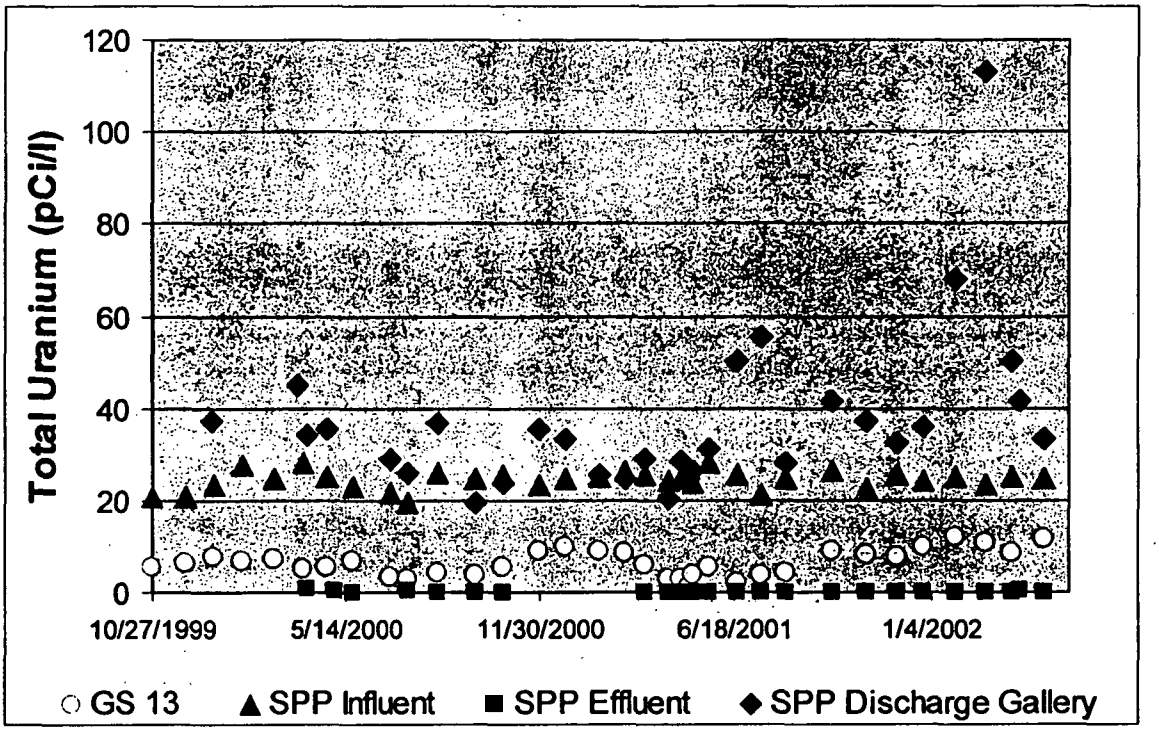
As indicated in Table 17 and Figure 18, uranium activities at GS13 were above 10 pCi/l for six months out of twelve, with the average below 10 pCi/l. However, sample results from the outfall of Pond A-4 (i.e., GS11, the RFCA point-of-compliance [POC] for uranium), remained below 10 pCi/l throughout the year ranging from 1.8 to 4.2 pCi/l for total uranium isotopes.

## Figure 17. Nitrate Concentrations in Solar Ponds Surface Water Locations



GS-13 nitrate concentrations are significantly lower than the discharge gallery indicating that phytoremediation is occurring in this area from the established plants at the discharge gallery, and that the higher flow volume in the stream dilutes the discharge gallery effluent.

**Figure 18. Uranium Activities in Solar Ponds Surface Water Locations**




### 4.2.2.3 Water Levels

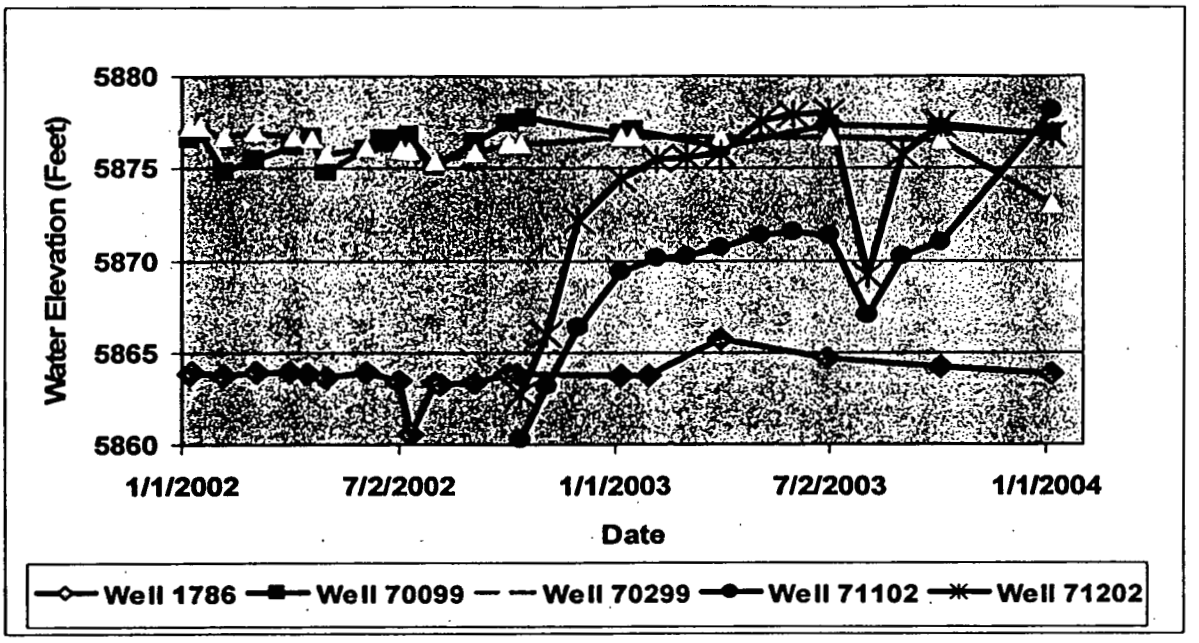
Water levels in the downgradient wells of the system were monitored monthly. These data are provided in Table 18 and Figure 19. The groundwater elevations in the downgradient wells were relatively stable during 2003. Groundwater elevations in the two new piezometers (71102 and 71202) increased fifteen to eighteen feet since installation. This rise might be a result of the water levels equilibrating in the tight formations after well installation or to a leak in the collection trench panels. The pump maintains water levels below the elevation of the potential leak, so water levels should drop with time in these piezometers if these are associated with a leaking panel.

**Table 18. Groundwater Elevations in Downgradient Solar Ponds System Wells (feet above msl)**

| Well | Jan 2003 | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Jan 2004 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1786 | 5863.78 | NM | NM | 5865.76 | NM | NM | 5864.7 | NM | NM | 5864.21 | 5863.88 |
| 70099 | 5876.91 | NM | NM | 5876.17 | NM | NM | 5877.39 | NM | NM | 5877.22 | 5876.91 |
| 70299 | 5876.73 | NM | NM | 5876.76 | NM | NM | 5876.73 | NM | NM | 5876.48 | 5873.07 |
| 71102 | 5869.37 | 5870.14 | 5870.24 | 5870.69 | 5871.39 | 5871.56 | 5871.38 | 5867.08 | 5870.27 | 5870.98 | 5878.11 |
| 71202 | 5874.43 | 5875.45 | 5875.61 | 5875.86 | 5877.53 | 5877.94 | 5878.07 | 5869.21 | 5875.76 | 5877.33 | 5876.85 |

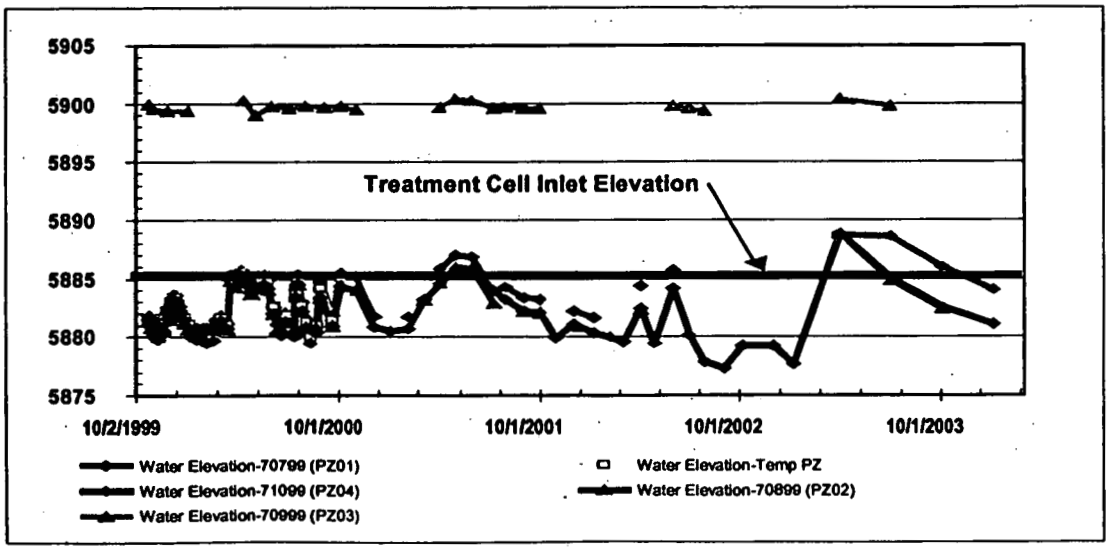
NM = water elevation not measured

**Figure 19. Solar Ponds Plume System 2003 Downgradient Well Water Elevations**




Water levels within the collection trench are monitored at five piezometers at 70799, 70899, 70999, 71099 and Temp PZ. The inlet to the treatment cell is 5,885 feet above msl and the bottom of the collection trench is approximately 5,875 feet above msl. As shown in Figure 20, water levels in four of the piezometers fluctuate between 5,880 and 5,890 feet above msl. The fifth piezometer (70999), located at the higher, east end of the trench, has a minimum measurable water elevation of 5,900 feet. By design, water collected in this part of the trench drains to the west. This piezometer is generally dry when the water level of the other piezometers drops to 5,880 feet; however during the last half of 2003 it was dry even though water levels were fairly high at other locations.

**Figure 20. Solar Ponds Plume Collection Trench Piezometer Water Levels**



The pump installed in 2002 is set to keep water in the sump below an elevation of 5880 feet, which should result in similar water elevations in the piezometers near the sump (all but 70999). The ability to maintain this level is limited by the capacity of the pump. The pump capacity was exceeded after the heavy March snowstorm and the water level rose in the trench. The water level continued to rise in the trench and remained elevated for some time, even with continued pump operation. Although the pump continued to operate and there was flow out of the treatment system, the elevated water levels in the trench indicated a partially plugged sump screen. The sump was redeveloped in 2004.

There is a significant difference in groundwater elevations between 70799 and the two nearby piezometers, 70899 and 71099, that has not been observed in the past. One potential explanation is that the pump in the collection trench causes fluctuation in water levels. Depending on when the measurements are made relative to the pump cycle, there may be a substantial amount of draw down when the pump is on.

### 4.3 Operations and Maintenance

Routine maintenance for the Solar Ponds Plume Treatment System consists of water level monitoring, solar-powered pump inspection, and sample collection. Because the iron is more dispersed within the treatment media, the media does not require raking or other routine maintenance. Based on vendor experience, it is expected that media replacement will be required 10 years after installation.

After the pump was installed in October 2002, initial flow rates were low, although in the past there has not historically been any flow in November. While flow was observed, the flow rate was too low to be measured. A drop off in flow rates beginning in late November 2002 was determined to be caused by sump well screen becoming plugged with fine-grained materials. The sump was redeveloped in March 2003 and much of the fine material was removed. The fines recovered from sump appear to be native material that collected in the trench over time and not the bentonite that was used in installation of both the collection trench and the sump. This indicates that clogging of the well screen was due to site conditions rather than improper sump design or installation. Redevelopment of the well screen in the sump was performed again in 2004. It is anticipated that redevelopment of the sump will not become routine; however, it is likely that it will have to be performed at least one more time.

Prior to 2003, the flow meter flume occasionally backed up from debris plugging the effluent line, producing erroneous readings. During 2003, the Treatment System flow meter flume was cleaned once and calibrated 3 times to prevent this from occurring. This was the only maintenance activity performed in 2003. Site staff performed regular water level monitoring and sample collection.

### 4.4 Conclusions

The Solar Ponds Plume Treatment System is operating properly and successfully. The effectiveness was evaluated by comparing the objectives stated in the Decision Document to the system performance. The objectives evaluated in Sections 4.4.1 and 4.4.2 are:

1. Protect North Walnut Creek by reducing the mass loading of nitrate to surface water and ensure that surface water standards are met in the Creek.

5. Evaluate effectiveness of reactive barrier system in removing nitrate.
6. Evaluate long-term effectiveness of the treatment system once it has been in operation for several years.

The evaluation also includes a comparison to preliminary decision rules for the project that are relevant to the proper and successful operation of the system as described below.

1. Steadily increasing water levels *(in the collection trench piezometers)* may be an indication that the media is plugged, requiring replacement.

   This has not occurred.

2. If effluent concentrations exceed system performance objectives, then monthly or more frequent sampling will be performed until the cause is determined. If a corrective action is required, then monthly effluent sampling will continue for at least three months after a corrective action is implemented to ensure that the action is sufficient.

   Effluent has not exceeded system performance objectives, as described for Objective 3.

3. Based on preliminary calculations provided by CDPHE, the current stream standard will be achieved if effluent concentrations are 500 mg/l. Effluent concentrations are expected to achieve this level. These preliminary calculations indicate that effluent concentrations must meet 50 mg/l to achieve surface water standards after 2009. Decision rules will be refined as performance monitoring trends are established and in anticipation of the decrease in the stream standard from 100 mg/l to 10 mg/l after 2009.

   Effluent nitrate levels have been generally below 50 mg/l, and well below 500 mg/l. However, system effluent is not the only contributor to nitrate in the stream. Higher nitrate concentrations than in the influent are observed at the discharge gallery. While concentrations at the measuring point in the stream, GS-13, are below 100 mg/l, they are expected to remain above 10 mg/l unless action is taken to address the levels at the discharge gallery. After evaluation of alternatives, an accelerated action is being proposed in the Draft Groundwater IM/IRA to address the nitrate plume in the discharge gallery area. Total uranium concentrations are also elevated at the discharge gallery, and the levels at GS-13 are above the stream standard for about 50% of the 2003 samples. However, the average total uranium is still slightly below the stream standard. The proposed accelerated action will also address elevated uranium in this area of the plume.

4. Groundwater monitoring will continue during and after the remedial action has been completed, as described in the IMP. Groundwater wells 1786 and 1386 currently monitor the drainage and will be, at a minimum, monitored for nitrate and uranium. An additional well cluster to the north of the barrier will be installed to provide additional data and for performance monitoring purposes. The frequency of sampling and analytical suites will be consistent with the IMP and will measure uranium and nitrate concentrations.

   The location and frequency of monitoring is described in the IMP.

5. Performance monitoring in the North Walnut Creek Drainage will be implemented at station GS13 to monitor changes in surface water quality as a result of the selected remedy. This location was selected because it is immediately downstream of where the groundwater plume intersects the drainage. The loading to the stream will be evaluated to determine long-term system performance and will be reported on an annual basis. In accordance with the Action Level Framework, if the stream concentrations exceed stream standards, then an evaluation will be performed after consultation with the regulators.

See discussion for Rule 3.

6. If stream standards are being met consistently at GS13 and if simple modeling techniques show that the stream standards would be met without treatment, based on the influent plume concentrations and flow rate, and the stream concentrations and flow rate that exist at that time, then treatment will be discontinued. This system is expected to continue operations until after Site closure when stream flow and concentrations have stabilized. The system will be abandoned in place as a flow-through system. System shutdown will be re-evaluated as part of the final Site CAD/ROD.

   It is not yet apparent that stream standards for nitrate and total uranium will be met consistently at GS-13, especially after the expiration of the temporary modification for nitrate.

### 4.4.1 Collection System Effectiveness

Upgradient concentrations are not significantly reduced from levels observed prior to system installation. The system is collecting significant volumes of contaminated groundwater as designed, and the solar-powered pump improves the collection performance. Maintenance of the pump well screen to clean soil fines will continue. Groundwater that daylights at the discharge gallery is downgradient of the collection system and is not collected. Groundwater collection in the discharge gallery area was not a part of the Decision Document.

Therefore Objective 1 is being met.

### 4.4.2 Treatment System Effectiveness

The system is effectively reducing the mass loading to surface water. Approximately 113 kilograms of nitrate contamination was removed by the treatment system during 2003, which is consistent with removal rates in previous years. Effluent concentrations meet RFCA surface water action levels and standards for total uranium and nitrate.

It does not appear at this time that the media is losing any treatment capacity, and the expected life is perhaps several more years before replacement is needed

Therefore Objectives 1, 5 and 6 are being met.

## 4.5 Planned Activities

The Solar Ponds Plume Treatment System has shown improved performance in collecting groundwater containing nitrate and uranium from the Solar Ponds Plume and the treatment cell continues to effectively treat the nitrate and uranium. The collection sump will most likely be redeveloped in the future. Currently, it is not clear whether the removal efficiency of the treatment system has diminished. Monitoring will continue and when steady-state conditions are met, it will be easier to determine if media replacement is necessary.

Performance monitoring data show that the average concentration at GS-13 for total uranium and nitrate is below 10 pCi/l and 100 mg/l, respectively. Based on system performance, a new Decision Rule is proposed to evaluate the need for continued operation of the system based on projected flow rates after closure at the current mass load to the stream. If evaluation of the

system shows that stream standards are projected to continue to be met, then the system will not be needed.

System performance continues to be evaluated by monitoring water levels and collecting water quality samples. Because water levels within the collection trench and nearby wells remain stable, these are monitored quarterly. Inspection of the flow meter continues to be performed monthly and the flume is cleaned as needed. The treatment system influent, effluent, discharge gallery, and GS13 are currently sampled monthly to monitor system performance and to determine if there are impacts to surface water. Based on these results, sampling will change to quarterly.

## 5.0 OU1 - 881 HILLSIDE GROUNDWATER TREATMENT SYSTEM

The OU1 - 881 Hillside groundwater collection and treatment system was installed in 1992. It consisted of a 1,435-foot-long french drain and a separate upgradient Collection Well. The French drain was decommissioned in 2000. Data are no longer collected at this location.

As a result of declining contaminant concentrations at the Collection Well, the Final Major Modification to the OU1 CAD/ROD, signed in January 2001 (DOE 2001), included continued extraction and treatment of groundwater from the Collection Well for an additional one-year period to verify this downward trend. In accordance with the terms of the Final Major Modification, water recovery and treatment from the Collection Well were terminated in April 2002, because of the continued decline in contaminant concentrations.

### 5.1 Project Activities and Status

The Collection Well continues to be sampled quarterly. The 2003 VOC analytes that are above detection limits are provided in Table 19. Figure 21 shows the trichloroethene concentrations in the collection well relative to time and the overall downward trend. Trichloroethene and other contaminants continued to remain below the RFCA Tier I Groundwater ALs throughout the year.

**Table 19. OU1 Collection Well Analytical Results for 2003 Sampling Event**

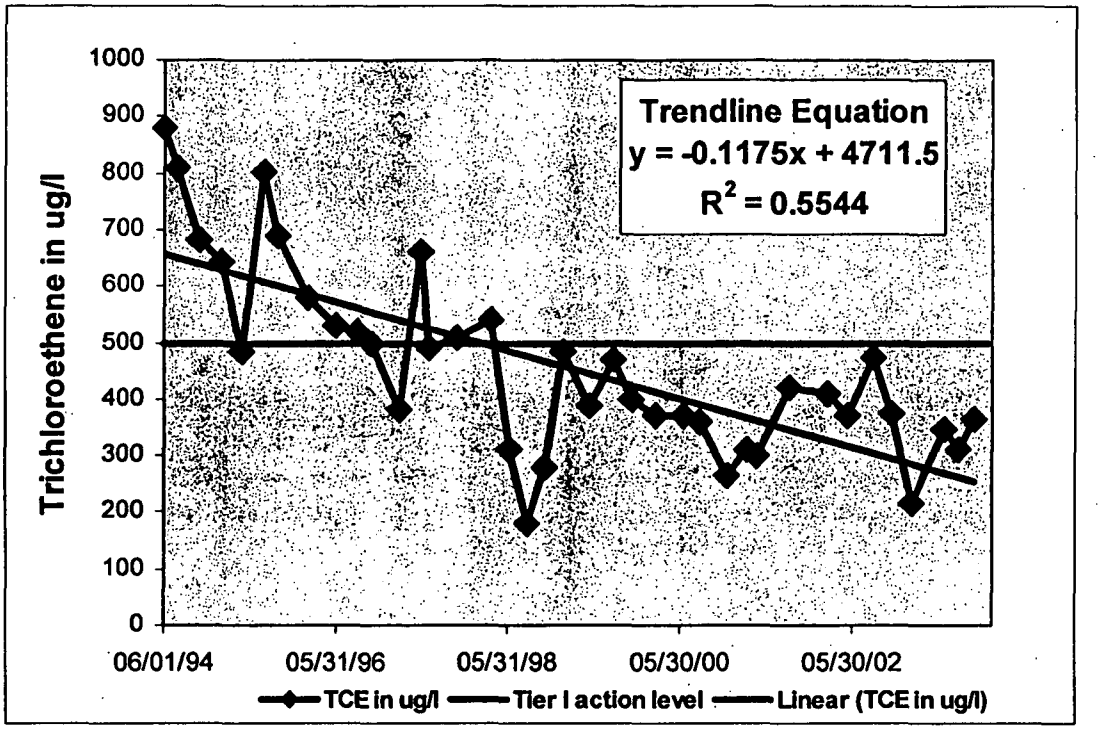
| Analyte | Concentration Range (ug/l) | RFCA Tier I Groundwater AL (ug/l) |
|---|---|---|
| Acetone | ND-3.9J | 365,000 |
| Carbon Tetrachloride | 0.31J –13.6 | 500 |
| Chloroform | 0.9 J- 2.6 | 10,000 |
| 1,1-Dichloroethene | 7.24 - 16 | 700 |
| Methylene Chloride | ND-1.2 | 500 |
| Tetrachloroethene | ND – 54.9 | 500 |
| 1,1,1-Trichloroethane | ND-2.2 | 20,000 |
| Trichloroethene | 214D – 363D | 500 |

D = Diluted

J = Detected at concentrations below the detection limit for this analysis

ND= Not Detected

**Figure 21. Trichloroethene Concentrations in the OU1 Collection Well**




## 6.0 OU7 - PRESENT LANDFILL PASSIVE SEEP INTERCEPTION AND TREATMENT SYSTEM

Groundwater contaminated with low concentrations of vinyl chloride and benzene discharges at a seep at the eastern end of the Present Landfill (OU7). These contaminants are periodically above RFCA Surface Water ALs.

The current passive seep interception and treatment system has operated since October 1998. The water is collected in a settling basin, flows through a pipe, down a set of stepped flagstones, and then over a six-foot-long bed of gravel before discharging into the East Landfill Pond. Flow is measured at the point of discharge. In accordance with the PAM for the OU7 Passive Seep Interception and Treatment System (DOE, 1998), water quality samples are collected from the treatment system discharge endpoint (SW00196), defined as the point six feet downstream from the last aeration step. Water released from the treatment system is collected in the East Landfill Pond, which is periodically pumped into Pond A-3 in North Walnut Creek. All water in North Walnut Creek passes through two RFCA POCs before it is discharged from the Rocky Flats Site.

The system is being removed, and a new system will be installed in accordance with the PL IM/IRA.

### 6.1 Volume of Seep Water Treated

The total volume of seep flow measured and treated in 2003 was 1,143,000 gallons. The volume treated by month is shown in Table 20.

**Table 20. Volume of Water Treated in the Present Landfill Passive Seep Interception and Treatment System During 2003**

| Month | Volume (gallons) |
|---|---|
| January | 17,709 |
| February | 32,805 |
| March | 96,157 |
| April | 110,942 |
| May | 161,117 |
| June | 157,210 |
| July | 143,699 |
| August | 126,632 |
| September | 90,877 |
| October | 75,621 |
| November | 67,635 |
| December | 62,685 |

## 6.2 Treatment Effectiveness

Samples are collected and analyzed semiannually, in June and December. Sampling requirements are based on the Performance Evaluation Report (K-H 2000) and the Sampling and Analysis Plan (SAP) for the OU7 Passive Aeration System (K-H 2001a). Analytical results are compared to RFCA Surface Water ALs to assess treatment system performance.

In accordance with the SAP, only VOC samples are currently collected and analyzed. All parameters analyzed in 2003 were within RFCA standards, except benzene. The benzene concentration ranged between 0.99 and 2.1 ug/l for all sampling events. The RFCA standard for Segment 4 is 1 ug/l. The other standards are shown in the Table 21.

**Table 21. Present Landfill Treatment System Water Analytes and Performance Standards**

| VOC Analytes | RFCA Surface Water Standard (ug/l) |
|---|---|
| Cis 1,2-Dichloroethene | 70 |
| Benzene | 1 |
| Chloromethane | 5.7 |
| Ethylbenzene | 680 |
| Methylene Chloride | 5 |
| Tetrachloroethene | 5 |
| Toluene | 1,000 |
| Trichloroethene | 2.7 |
| Vinyl Chloride | 2 |
| Xylene (Total) | 10,000 |

*RFCA values are based on RFCA Attachment 5, Table 1, Surface Water Action Levels & Standards, March 2000.*

The SAP states that if a RFCA standard is exceeded in the semiannual monitoring, then a sample will be collected and analyzed the month following receipt of validated data. Preliminary data are received from the analytical laboratory within a month of sampling and validated results are received one month later. A sample taken in December 2002 was 1.6 ug/l and a follow-up

sample was taken in January of 1.3 ug/l. Monthly samples continued after that. All samples were just slightly over the 1-ug/l limit except the May 2003 sample. The results are shown in Table 22 for the period June 2000 through January 2004.

**Table 22. Benzene Concentrations in Present Landfill Treatment System Effluent**

| Month | Benzene Concentration (ug/l) |
|---|---|
| June 2000 | 1 |
| July 2000 | 1 (special sample) |
| December 2000 | 2 |
| March 2001 | 1 |
| June 2001 | 2 (duplicate sample concentration was 1 ug/l) |
| September 2001 | 1.4 |
| December 2001 | 0.3 J |
| June 2002 | 0.94 J |
| December 2002 | 1.6 |
| January 2003 | 1.3 |
| February 2003 | 1 |
| March 2003 | 1.2 |
| April 2003 | 1.5 |
| May 2003 | 0.99 |
| June 2003 | 1.3 |
| July 2003 | 1.7 |
| August 2003 | 1.3 |
| September 2003 | 1.5 |
| October 2003 | 1.6 |
| November 2003 | 2.1 |
| December 2003 | 1.6 |
| January 2004 | 1.6 |

J = Estimated below detection limit

The results for September 2001 through December 2003 were reported to tenths or hundredths of a microgram due to differences in protocols and reporting between different laboratories.

The water discharging from the Present Landfill Passive Seep Interception and Treatment System meets all RFCA Surface Water ALs, except for benzene. As stated in the RFCA Action Level Framework (ALF), the Segment 5 temporary modification to the stream standard for benzene is 5 ug/l, and the Segment 4 stream standard is 1 ug/l (the RFCA AL is applied as a standard in Segment 4). The temporary modification is in place until December 31, 2009. While the East Landfill Pond is located in Segment 4, water from the pond is transferred about once a year to the A-Series Ponds in Segment 5. Benzene is not an analyte of interest at the POCs at Pond A-4 or Walnut Creek and Indiana Street.

Although most of the samples for benzene were above one ug/l for the year, it is not apparent whether or not this represents an increase because concentrations are so close to the detection limit for benzene. There does not appear to be a clear relationship between the flow rate or total flow and the benzene concentration. It is likely the influent concentration to the system is the biggest factor affecting the concentration in the effluent. It also appears likely that the benzene concentration will continue to periodically exceed 1 µg/l at this location, pending installation of the new treatment system.

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### 6.3 Conclusions and Planned Changes

Monitoring will continue under the PAM (DOE, 1998) until the system is removed and replaced as described in the PL IM/IRA.

## 7.0 PU&D YARD PLUME TREATABILITY STUDY

A plume of VOC-contaminated groundwater originated from a contaminant source located in the PU&D Yard at RFETS. Investigation results indicate that subsurface VOC contamination was present in only a few locations and the primary contaminant is tetrachloroethene (K-H 2001b). A treatability study was conducted to evaluate the effectiveness of HRC® for enhancing biodegradation of the VOCs in the groundwater and soil at the PU&D Yard Plume (K-H 2001b, K-H 2001c). HRC® is a proprietary, environmentally safe, food quality, polylactate ester formulated for slow release of lactic acid upon hydration.

The HRC® stimulated rapid degradation of chlorinated VOCs found in groundwater and soil at this location by making low concentrations of hydrogen available to the resident microbes to use for dechlorination. The HRC® was a one-time application that, according to the manufacturer, Regenesis, was expected to stimulate contaminant degradation at the project site for approximately one and a half years. However, because some of the HRC® was inserted above the water table and the water table fluctuated considerably, it appears that additional degradation of contaminants within the vadose zone has continued to occur for three years including 2003 and will likely continue to occur for an unknown duration.

### 7.1 Project Activities

The treatability study is located within the source area and area of highest groundwater contamination within the PU&D Yard Plume (Figure 22). A monitoring (Well 30900) was installed in this area immediately adjacent to Borehole 17497, where the highest concentrations of VOCs in soils were detected. An additional monitoring well (Well 31001) was installed slightly downgradient of the source area in January 2001 as part of this study. Baseline groundwater samples were collected from these wells prior to insertion of the HRC®.

Beginning in February 2001, 16 material insertion points (MIPs) were used to place over 800 pounds of HRC® into the subsurface within a 10-foot by 6-foot area within the source area of the plume (Figure 23). The initial grid consisted of nine points. Additional Geoprobe™ boreholes used as MIPs were spaced between these initial locations, biased to the upgradient part of the source area. HRC® insertion was completed on March 1, 2001. Subsurface conditions were allowed to stabilize for two months before monthly sampling was initiated on April 30, 2001.

### 7.2 Treatment Effectiveness

Results from the initial baseline samples and the monthly and quarterly sampling events through 2003 are reported in Table 23. Earlier samples from the pre-existing monitoring well (Well 30900) and the groundwater sample from MIP3 are also included for completeness. Concentrations of tetrachloroethene, trichloroethene, and cis 1,2-dichloroethene in the source area well (Well 30900) increased after insertion of the HRC®, then decreased (Figures 24 and 25). According to Regenesis, 70 to 80 percent of project sites show an initial increase in VOC concentrations before a downward trend is observed. Trichloroethene and cis 1, 2-dichloroethene are common degradation products of tetrachloroethene.

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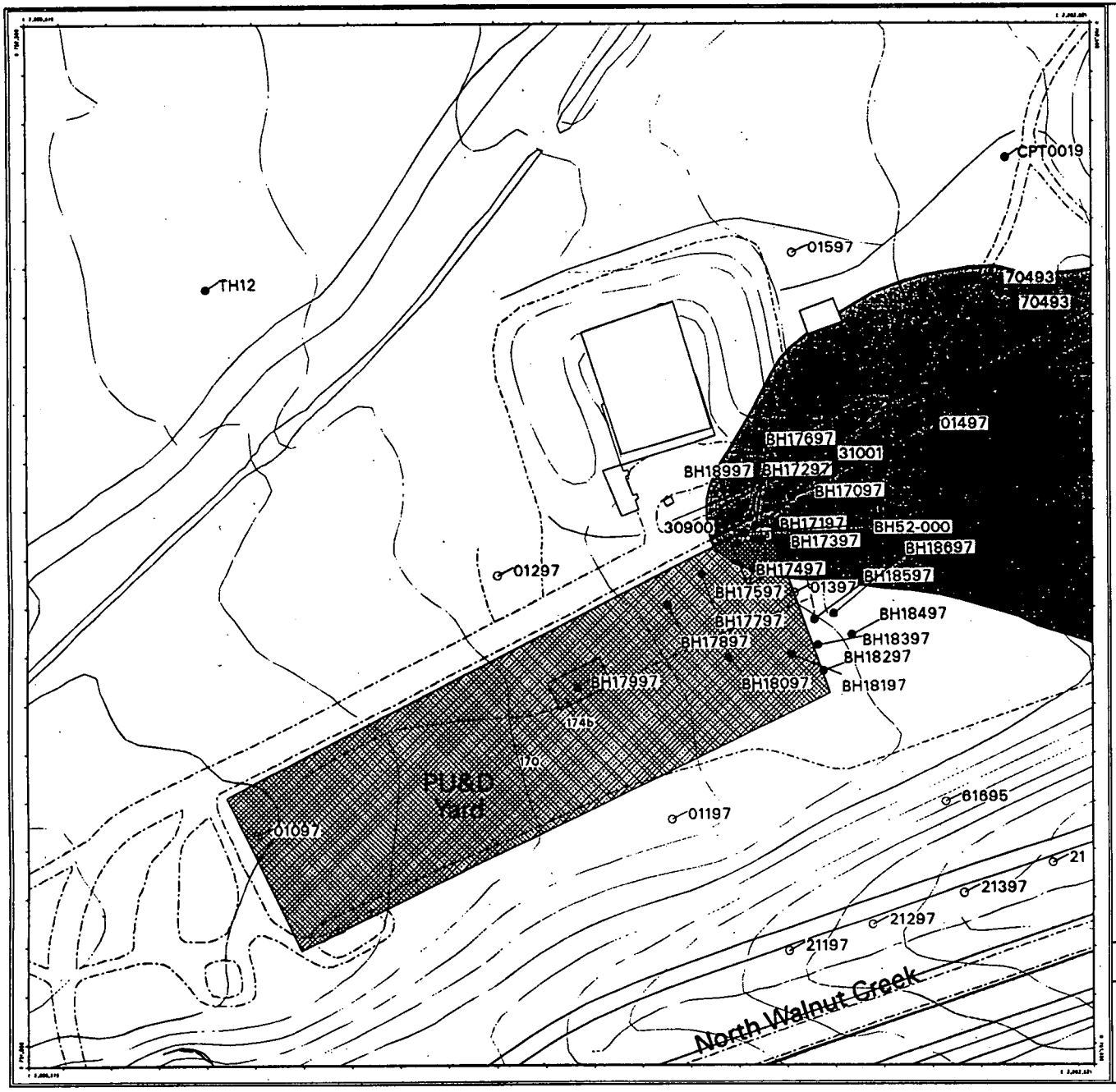


# Figure 22
## PU&D Yard Groundwater VOC Plume Project Area

**EXPLANATION**

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations
- Abandoned Monitor Well
- Composite VOC Groundwater Plume (concentration equal to MCL)
- PU&D Yard IHSS

**Standard Map Features**

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (5-Foot)
- Paved roads
- Dirt roads

NOTES:
Source of GIS data available upon request.

N

Scale = 1 : 2670
1 inch represents approximately 214 feet

50 0 100 200 Ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: CH2MHILL

Prepared for: KAISER-HILL

March 27, 2003

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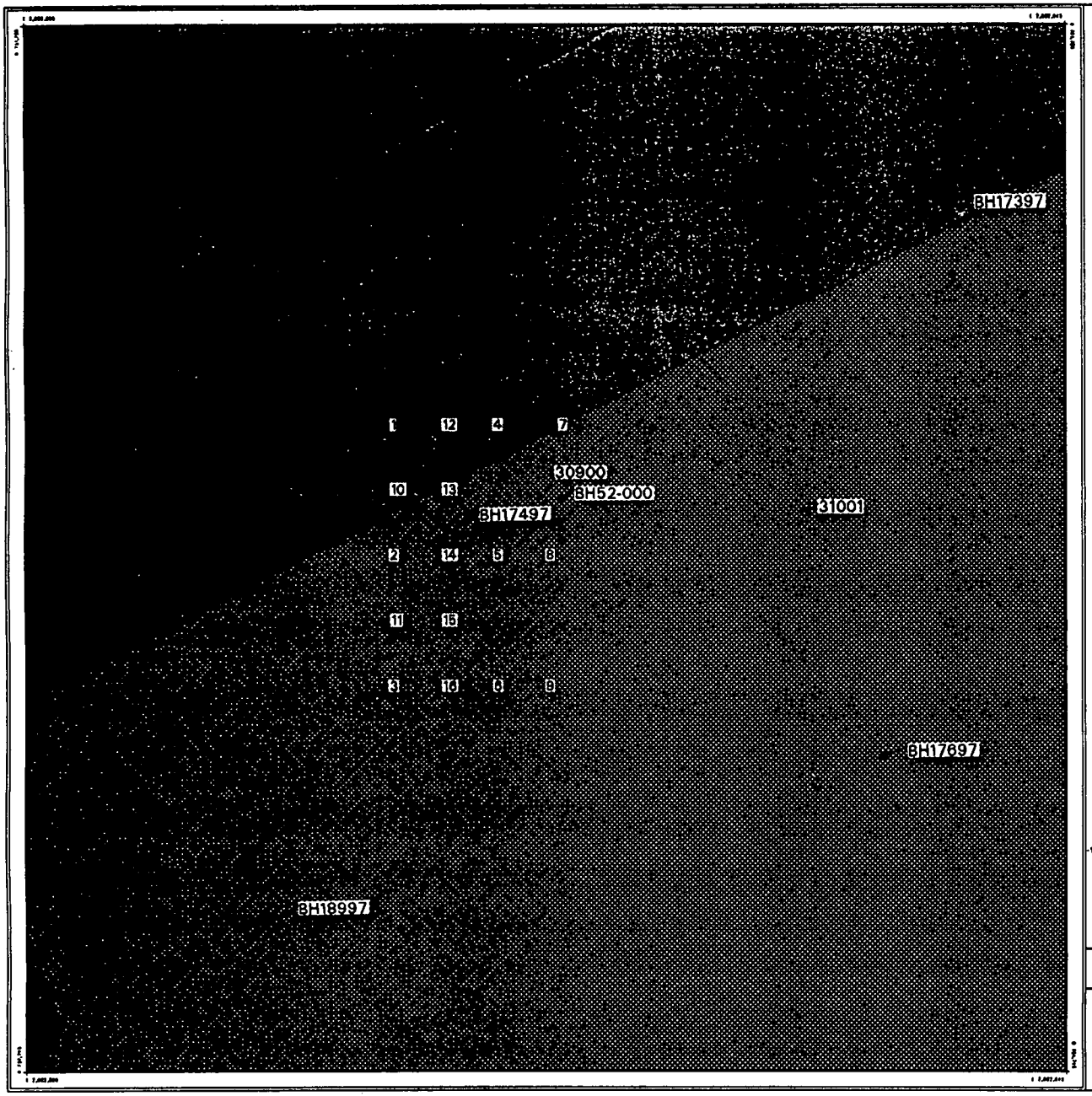


# Figure 23

## PU&D Yard
## Groundwater VOC Plume
## Material Insertion Point Configuration

**EXPLANATION**

- PU&D Yard Monitoring Well
- Groundwater Monitor Well UHSU Surficial Material
- Groundwater Monitor Well UHSU Bedrock
- Groundwater Monitor Well LHSU Bedrock
- Borehole Locations
- Abandoned Monitor Well
- Material Insertion Point
- Composite VOC Groundwater Plume (concentration equal to MCL)
- PU&D Yard IHSS

**Standard Map Features**

- Buildings and other structures
- Landfill Pond
- Streams, ditches, or other drainage features
- Fences and other barriers
- Topographic Contour (5-Foot)
- Paved roads
- Dirt roads

NOTES:
Source of GIS data available upon request.

Scale = 1 : 70
1 inch represents approximately 6 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

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March 27, 2003

NT_Svr w:/projects/fy2003/03-0341/pud-yard-mip_fig13a.aml

## Table 23. Treatability Study Results (ug/l)

| Location | Sample Date | Tetrachloro-ethene | Trichloro-ethene | Cis 1,2 Dichloro-ethene | Trans 1,2, Dichloro-ethene | 1,1-Dichloro-ethene | Vinyl Chloride | Ethene |
|---|---|---|---|---|---|---|---|---|
| MIP3 | 2/20/01 | 4.9 | ND | ND | ND | ND | ND | - |
| 30900 | 10/21/00 | 96 | 7.4 | 53.1 | ND | ND | ND | - |
| | 2/7/01 | 120 | 7 | 78 | 0.5 | 0.5 | ND | - |
| | 4/30/01 | 180 | 11 | 110 | 0.1 | 0.4 | ND | - |
| | 5/30/01 | 350 | 23 | 210 | ND | ND | ND | - |
| | 6/27/01 | 240 | 15 | 140 | 0.2 | 0.5 | ND | 2 |
| | 7/31/01 | 93.6 | 10.6 | 91.4 | 0.19 | 0.31 | 0.21 | ND |
| | 8/28/01 | 116 | 15 | 100 | ND | 0.39 | ND | ND |
| | 10/1/01 | 50 | 5 | 77 | ND | ND | ND | ND |
| | 10/31/01 | 34 | 3.1 | 36 | ND | ND | ND | ND |
| | 11/29/01 | 30 | 3.6 | 45 | ND | 0.28 | ND | ND |
| | 1/7/02 | 18.5 | 2.92 | 88.6 | 0.212J | ND | ND | ND |
| | 2/18/02 | 9.8 | 1.9 | 140 | ND | 0.38 | ND | ND |
| | 3/4/02 | 8.25 | 1.37 | 188 | 0.568J | 0.51J | ND | ND |
| | 4/1/02 | 15 | 2.7 | 160 | ND | 0.42 | ND | ND |
| | 5/2/02 | 7.5 | 1.6 | 200 | ND | 0.45 | ND | ND |
| | 7/1/02 | 46 | 9 | 460 | 0.58 | 1.5 | ND | ND |
| | 10/3/02 | 23 | 6.1 | 31 | ND | 1 | ND | ND |
| | 1/7/03 | 7 | 0.96 | 540 | 0.87 | 1.1 | ND | 3.43 |
| | 4/1/03 | 230 | 42 | 2700 | 1.1 J | 5.4 | ND | 5.20 |
| | 7/1/03 | 110 | 31 | 1700 | 1.5 J | 2.6 | ND | - |
| | 10/2/03 | 77 | 20 | 1100 | ND | 2.2 | ND | - |
| 31001 | 2/7/01 | 18 | 5.5 | 1.2 | ND | 2.6 | ND | - |
| | 4/30/01 | 130 | 20 | 52 | 0.1 | 4 | ND | - |
| | 5/30/01 | 41 | 18 | 4 | ND | ND | ND | - |
| | 6/27/01 | 120 | 25 | 38 | ND | 1 | ND | ND |
| | 7/31/01 | 105 | 16.3 | 189 | 0.13 | 1.49 | 0.12 | ND |
| | 8/29/01 | 81 | 22 | 93 | ND | ND | ND | ND |
| | 10/1/01 | 67 | 7.7 | 71 | ND | 0.6 | ND | ND |
| | 11/1/01 | 18 | 4.8 | 30 | ND | 0.65 | ND | ND |
| | 11/30/01 | 15 | 3.7 | 24 | ND | 0.47 | ND | ND |
| | 1/07/02 | 12 | 3.78 | 12.1 | ND | 0.88 | ND | ND |
| | 2/18/02 | 37 | 9.4 | 13 | ND | 3.3 | ND | ND |
| | 3/4/02 | 34 | 9.23 | 9.27 | ND | 1.67 | ND | ND |
| | 4/1/02 | 30 | 6.7 | 10 | ND | 2.6 | ND | ND |
| | 5/2/02 | 25 | 6.6 | 12 | ND | 2.3 | ND | ND |
| | 7/1/02 | 35 | 16 | 85 | ND | 2.2 | ND | ND |
| | 10/3/02 | 27 | 2.4 | 79 | ND | ND | ND | ND |
| | 1/7/03 | 16 | 4.2 | 36 | ND | 1.7 | ND | ND |
| | 4/1/03 | 17 | 1.5 | 26 | ND | 0.25 J | ND | ND |
| | 7/1/03 | 12 | 4.8 | 610 | ND | 2.3 J | ND | ND |
| | 10/2/03 | 1.1 | 0.67 J | 310 | 0.26 J | 1.6 | 0.79 J | ND |
| Groundwater Tier I AL | | 500 | 500 | 7,000 | 7,000 | 700 | 200 | |
| Groundwater Tier II AL | | 5 | 5 | 70 | 70 | 7 | 2 | |

ND - not detected
\- not analyzed

**Figure 24. Tetrachloroethene and Degradation Products Concentration versus Time in Well 30900**

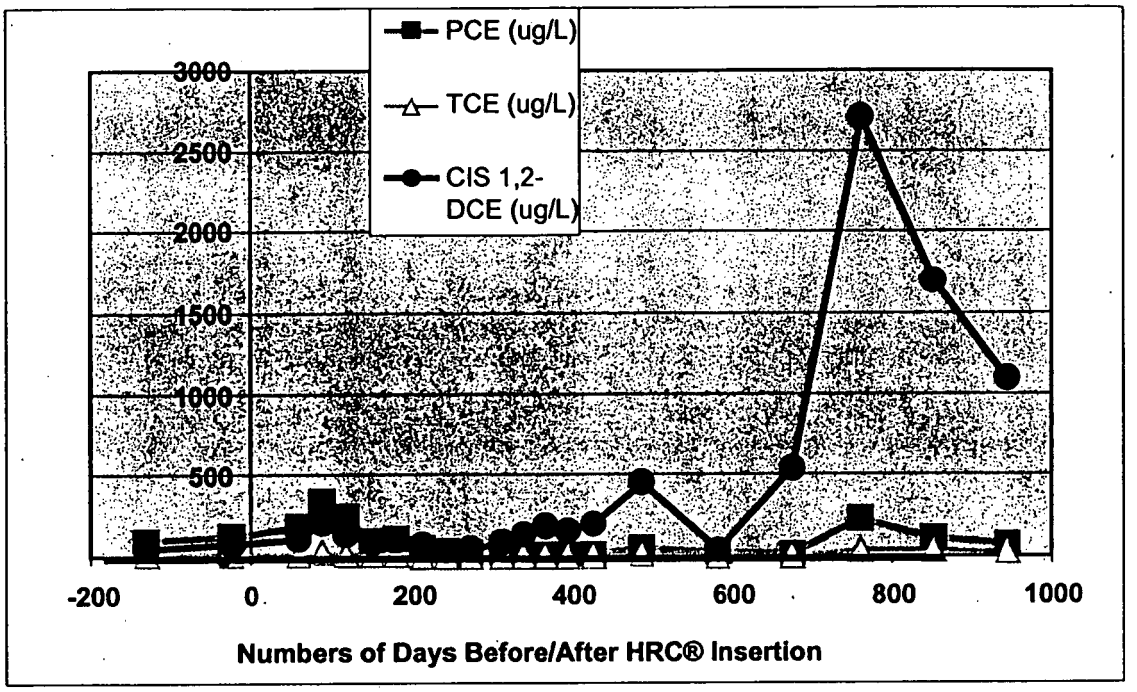
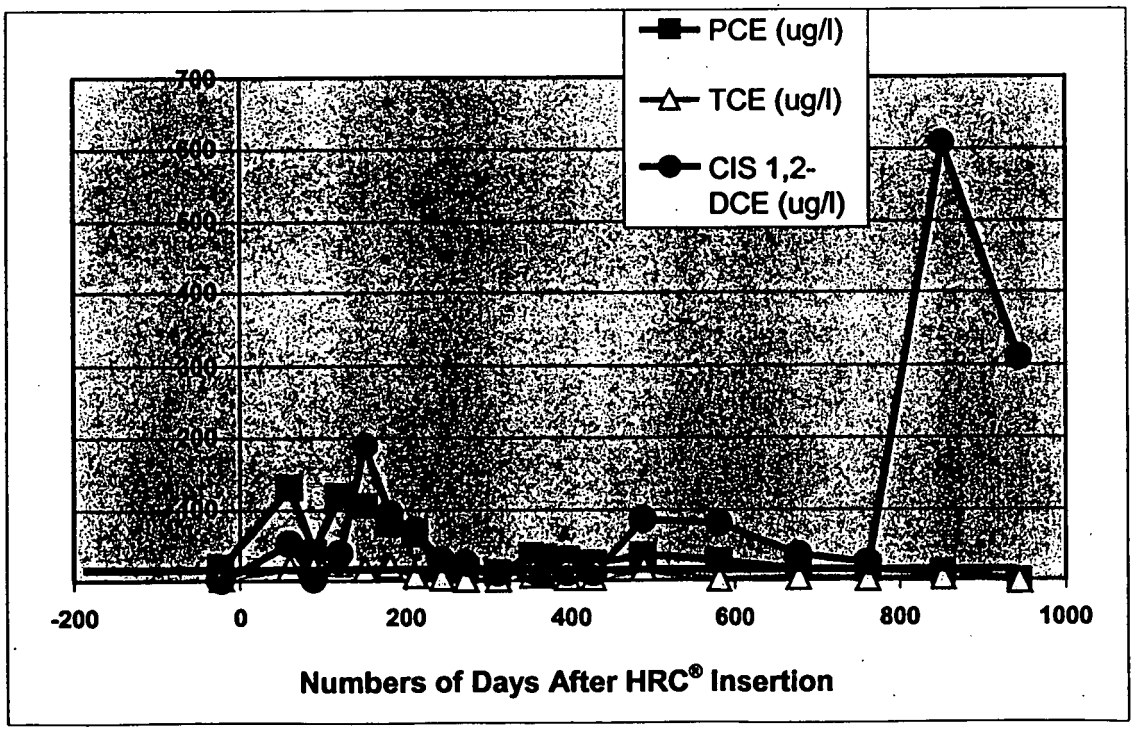



**Figure 25. Tetrachloroethene and Degradation Products Concentration versus Time in Well 31001**

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It was anticipated that this downward trend would continue; however; the cycle repeated itself when the water table rose again in the spring of 2002 and again in the spring of 2003 (Table 24). In both 2001 and 2003 the water table rose close to ground surface. As the water table rises, contaminants present in the vadose zone are liberated, causing an increase in groundwater contaminant concentrations.

**Table 24. Depths to Water by Calendar Year (Well 30900)**

| Year | Average (Feet) | Minimum (Feet) | Maximum (Feet) |
|---|---|---|---|
| 2001 | 9.4 | 3.68 | 14.21 |
| 2002 | 14.4 | 12.1 | 15.23 |
| 2003 | 9.0 | 3.12 | 15.42 |

Although the concentration of tetrachloroethene increased, it did not exceed past highs in the source area, both trichloroethene and cis 1,2-dichloroethene did. Furthermore, the highest levels of cis 1,2 dichloroethene were seen downgradient. This could be an indication of a more robust microbial population since it appears that more contaminants were liberated from the soil and also a greater quantity was degraded. Based on previous years experience, it is anticipated that the cycle will repeat again in 2004, although the effect might not be as pronounced. As indicated on Figure 25, data from the downgradient well (Well 31001) show a similar pattern.

The initial, expected increase in tetrachloroethene in groundwater and subsequent releases was most likely due to one or a combination of the following conditions:

- HRC® has surfactant properties. Changes in the surface tension of free phase solvents in the soil pores causes more solvent to be released from the pores.
- A change in the relative solubility of the individual VOCs due to the presence of lactic acid in the aqueous phase that would allow more VOCs to go into solution.
- Other changes in liquid and organic phases caused by changes in pH, temperature, oxidation-reduction potential (ORP), etc. caused by addition of lactic acid or by increases in biological activity.
- A seasonal increase due to the rising water table with dissolution and release of additional contaminants from the vadose zone.

As shown on Figure 26, as the water table rises, higher contaminant concentrations are see in the source area well (Well 30900). HRC® is present in the vadose zone and as the water table rises into the vadose zone, it is released, inducing more biological activity. At the same time, additional contaminants are available since more contaminated soil is now below the water table and available for biological and chemical degradation. The lower concentrations of tetrachloroethene are probably due to less tetrachloroethene being released to the aquifer and to more tetrachloroethene degrading.

Figures 27 and 28 show the mole fraction (in percent) in wells 30900 and 31001. The relative amounts of degradation byproducts increase as additional degradation occurs and the zone of anaerobic degradation increases. Eventually these byproducts are also degraded and their mole fraction decreases as it did in the source area in October of 2002. The release of additional tetrachloroethene in the spring of 2003 appears to have added additional degradation products

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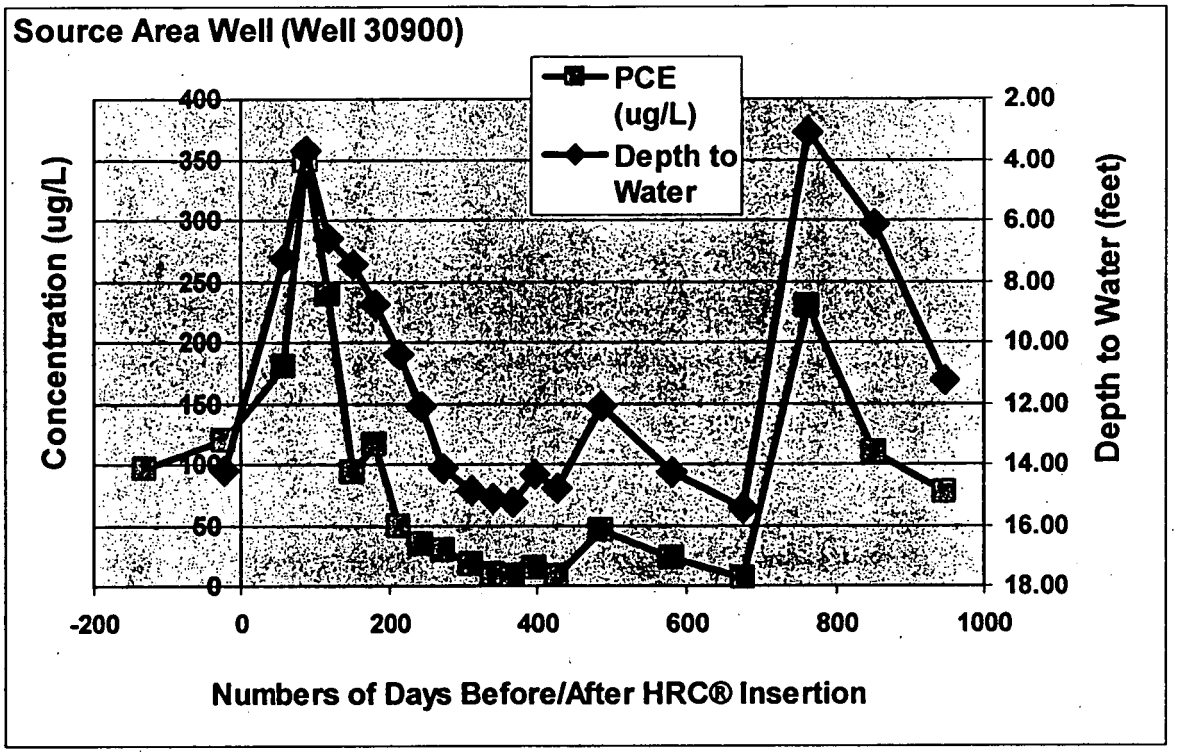
and again increasing the ratio of cis 1,2 dichloroethene to the other species suggesting that the area of biological reduction increased again as was seen in 2001.

**Figure 26. Tetrachloroethene Concentration and Depth to Water in Source Area Well 30900 versus Time**




Figures 24 and 27 also show cis 1,2-dichloroethene occur at higher concentrations in the source area than downgradient. Cis 1,2-dichloroethene is more resistant to anaerobic bacterial degradation than tetrachloroethene and its other byproducts. However, according to Regenesis, aerobic bacteria can more readily degrade it. In the downgradient well (31001), as conditions become more aerobic, the cis 1,2-dichloroethene appears to be readily degraded to vinyl chloride and then to ethene. Vinyl chloride is so readily degraded that it only appears occasionally in very low concentrations. Likewise, it is not anticipated that ethene would be found in detectable quantities since it degasses quickly. However it does appear in detectable quantities when the cis 1,2-dichloroethene is the highest in the source area. This could indicate that some cis 1,2- dichloroethene is completely degrading in the source area. No ethene has ever been detected in the downgradient well possibly due to the low concentrations of cis 1,2-dichloroethene.

Initial increases in concentrations after HRC® and when the water table rises indicate that VOCs are being transferred from the soil to an aqueous phase, potentially accelerating both soil and water remediation. Typically, the VOCs trapped in the saturated and vadose zones have been the most difficult phase to remediate and continue to act as a contaminant source. Since these are being mobilized and then biologically degraded along with contaminants in the dissolved phase, this is a much more robust treatment methodology than simply biologically degrading the dissolved fraction or DNAPL pools below the water table.

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**Figure 27. Mole Fraction Percent of Tetrachloroethene in Source Area Well 30900 Relative to its Degradation Products Over Time**

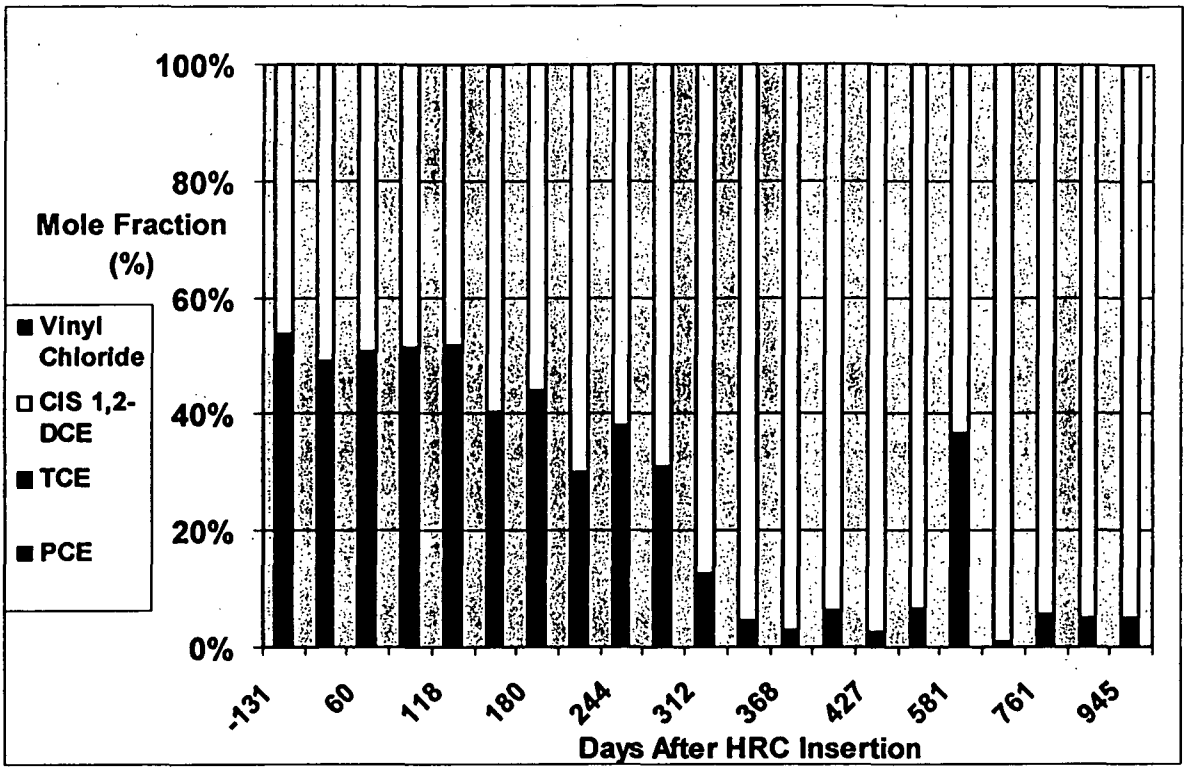
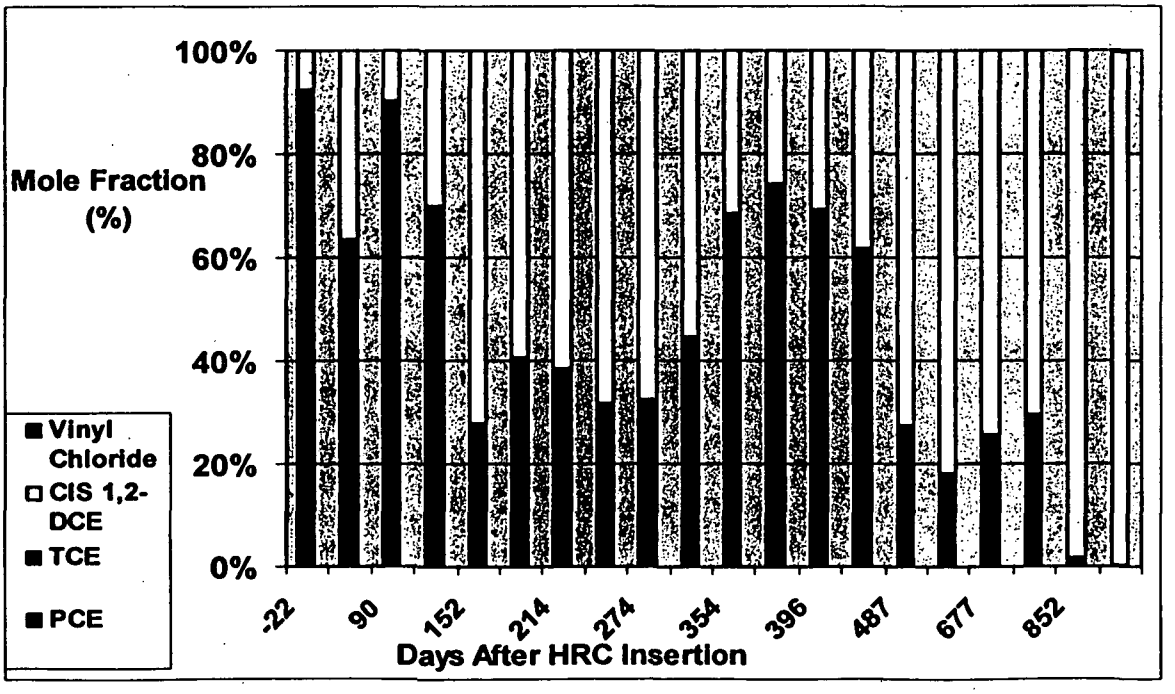


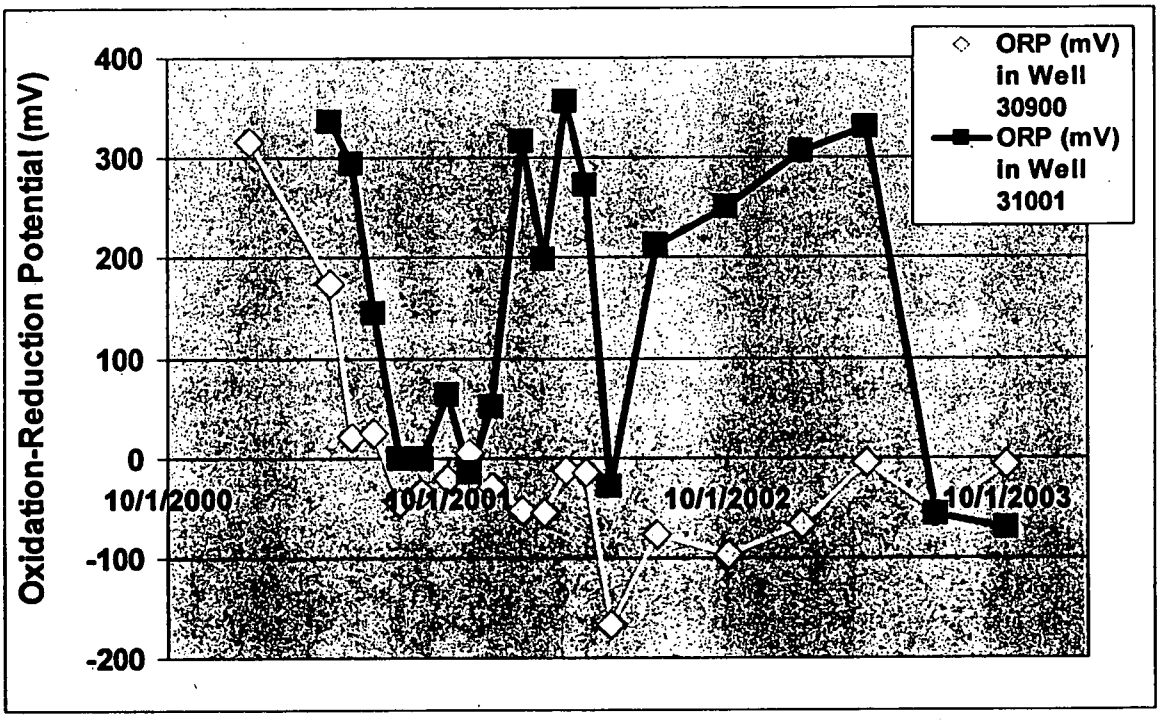

**Figure 28. Mole Fraction Percent of Tetrachloroethene in Downgradient Well 31001 Relative to its Degradation Products Over Time**



As shown in Table 23, the presence of other degradation products such as trans 1,2-dichloroethene, 1,1-dichloroethene, vinyl chloride, and ethene demonstrates that degradation is occurring because these contaminants were not associated with releases at the PU&D Yard. The increase in the ratio of degradation products relative to tetrachloroethene concentrations also confirms that degradation is occurring. Figures 28 and 29 show this increase in degradation products over time.

The area of anaerobic degradation appears to expand and contract with water table fluctuations. The area expands as the HRC® is released and contracts as it is consumed. Figure 29 shows how ORP changes with time in both the source area well (Well 30900) and in the downgradient well (Well 31001). The measurements were made using a silver/silver chloride electrode with a three-normal potassium chloride filling solution. Reduced conditions in the source area well increased as the anaerobic bacterial community developed. Since it is at the center of the community, it has remained in a reduced state while the downgradient well has responded to the expansion and contraction of the biological community

**Figure 29. Oxidation Reduction Potential in PU&D Yard Wells versus Time**




Downgradient, the area of reduced conditions increased but then contracted when the HRC® was consumed and the area of anaerobic degradation shrank. When the water table rose, and more HRC® became available, the area of reduced conditions again expanded. Since startup, this cycle appears to be occurring yearly. Figure 29 also shows seasonal variations in the downgradient well. When more HRC® was released in the spring, the area of anaerobic bacteria expanded to include this well and the oxidation-reduction potential dropped. This cycle appears to affect cis 1,2-dichloroethene the most.

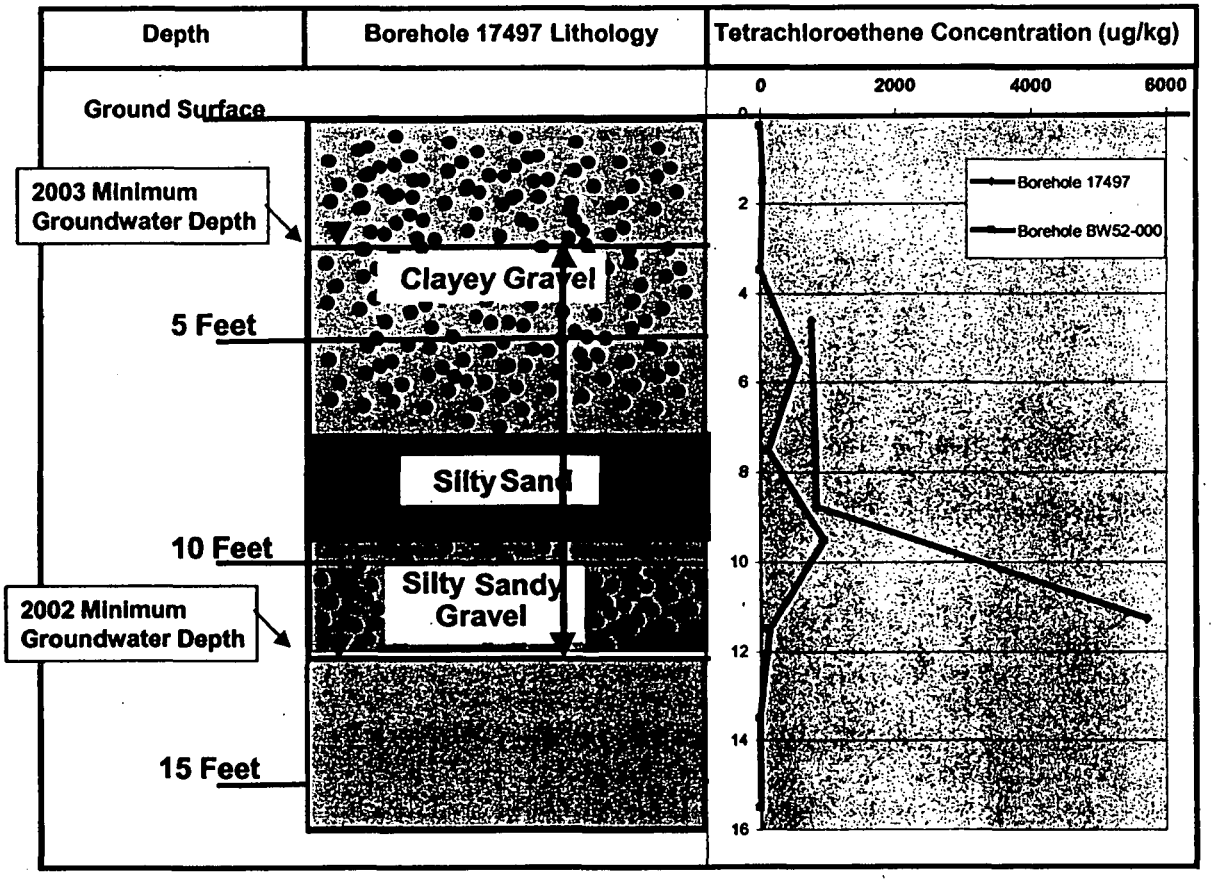
When the water table rises, the area of reduced conditions and anaerobic activity get larger, and the concentration of cis 1,2-dichloroethene increases as shown on Figures 25 and 26. Farther

out from this anaerobic core, cis 1,2 dichloroethene degradation is probably occurring as it does when the core shrinks in the fall with a concurrent rise in the oxidation-reduction potential in Well 31001.

In September 2002, Borehole 17497 was twinned with a new borehole (Borehole BW52-000) to determine whether soil concentrations were significantly reduced. Samples were taken at two-foot intervals from 0.5 feet below the surface down to 15.5 feet below the surface and analyzed for VOCs.

Figure 30 shows the differences in tetrachloroethene concentration with depth between the original sample and the sample after treatment. Prior to HRC® insertion, the highest concentration of tetrachloroethene was 5,700 micrograms per kilogram (ug/kg) occurring below the water table at a depth of 11.25 feet. The more recent sample from the corresponding borehole interval had a tetrachloroethene concentration of 140 ug/kg or a 97.5 percent reduction in concentration. As can be seen in Figure 30, there appears to have been a reduction in tetrachloroethene both above and below the water table, although there are no pre-existing data from beneath the water table.

**Figure 30. Lithology and Soil Concentrations of Tetrachloroethene (ug/kg) Versus Depth (feet from surface) in the Source Area**




Also shown on Figure 30 is the minimum groundwater depths for 2002 and 2003. This illustrates how groundwater levels rise and fall through contaminated vadose zone soils, the likely source

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of both additional HRC and contaminants. Because this rise in groundwater elevation was coupled with increased degradation, it is assumed that soil concentrations were further reduced.

### 7.3 Conclusions and Work Planned

The continued decrease in tetrachloroethene and appearance of its byproducts provide direct evidence that the contaminant plume is being degraded. However, quarterly monitoring will continue until sufficient data are collected to establish the effectiveness of the HRC®. Other than monitoring, no additional work is planned for this site. A treatability study report (K-H 2001c) was completed in October 2001 and provides additional information on the treatability study not contained in this document.

This technology is effective on contaminants in the dissolved phase but also is effective on the organics trapped in the soil that would normally act as a continuous source of contaminants. Pump and treat systems and passive systems such as the Mound Site Plume and East Trenches Plume treatment systems only treat the contamination in the groundwater plume. These systems are expected to operate for many years since the trapped organics will continue to feed these plumes. With enhanced *in situ* biodegradation, organic compounds are liberated from the soil and consumed over a relatively short period of time. In addition because of groundwater fluctuations, much of the contaminants in the vadose zone also appear to have been removed and destroyed.

Enhanced *in situ* biodegradation appears to be a viable technology for future groundwater remediation at Rocky Flats. It is best suited for areas with organic compounds trapped below the water table although it could be a viable technology above the water table. In areas where there are large quantities of free phase organic compounds, other technologies might be more viable or might be combined with enhanced *in situ* biodegradation. This technology is not as effective in some areas where groundwater flows into surface water since there is insufficient residence time to fully degrade all of the degradation products prior to reaching surface water.

## 8.0 REFERENCES

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